DAM SAFETY INSPECTIONS: ROUTINE VS. NON-ROUTINE

Richard E. Smith

Dam Safety Program Manager

Seattle District

17 May 2016

U.S.ARMY

US Army Corps of Engineers

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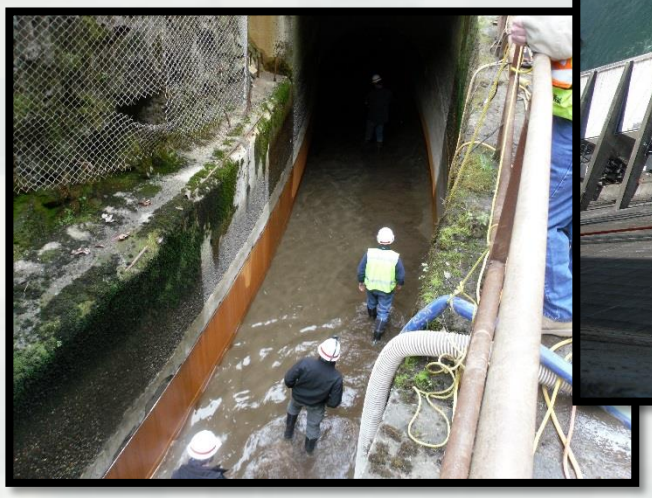
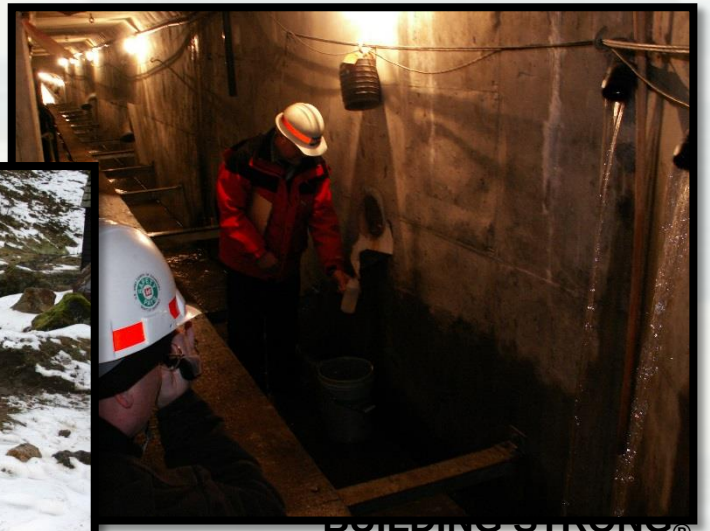
Types of Inspections



Routine

vs.

Non-Routine



USACE Routine Inspections

- Daily Operations
- Annual Inspections
- Periodic Inspections
- Periodic Assessments

Training Opportunities

RECLAMATION
Managing Water in the West

TRAINING ANNOUNCEMENT

Seminar on Safety Evaluation of Existing Dams (SEED)
(Domestic Audience) – 2016

This training will be Monday June 20, 2016, through Friday June 24, 2016.
REGISTRATION CLOSES JUNE 1, 2016.

Location: Sheraton Denver West Hotel, 360 Union Boulevard, Lakewood, Colorado, 80228

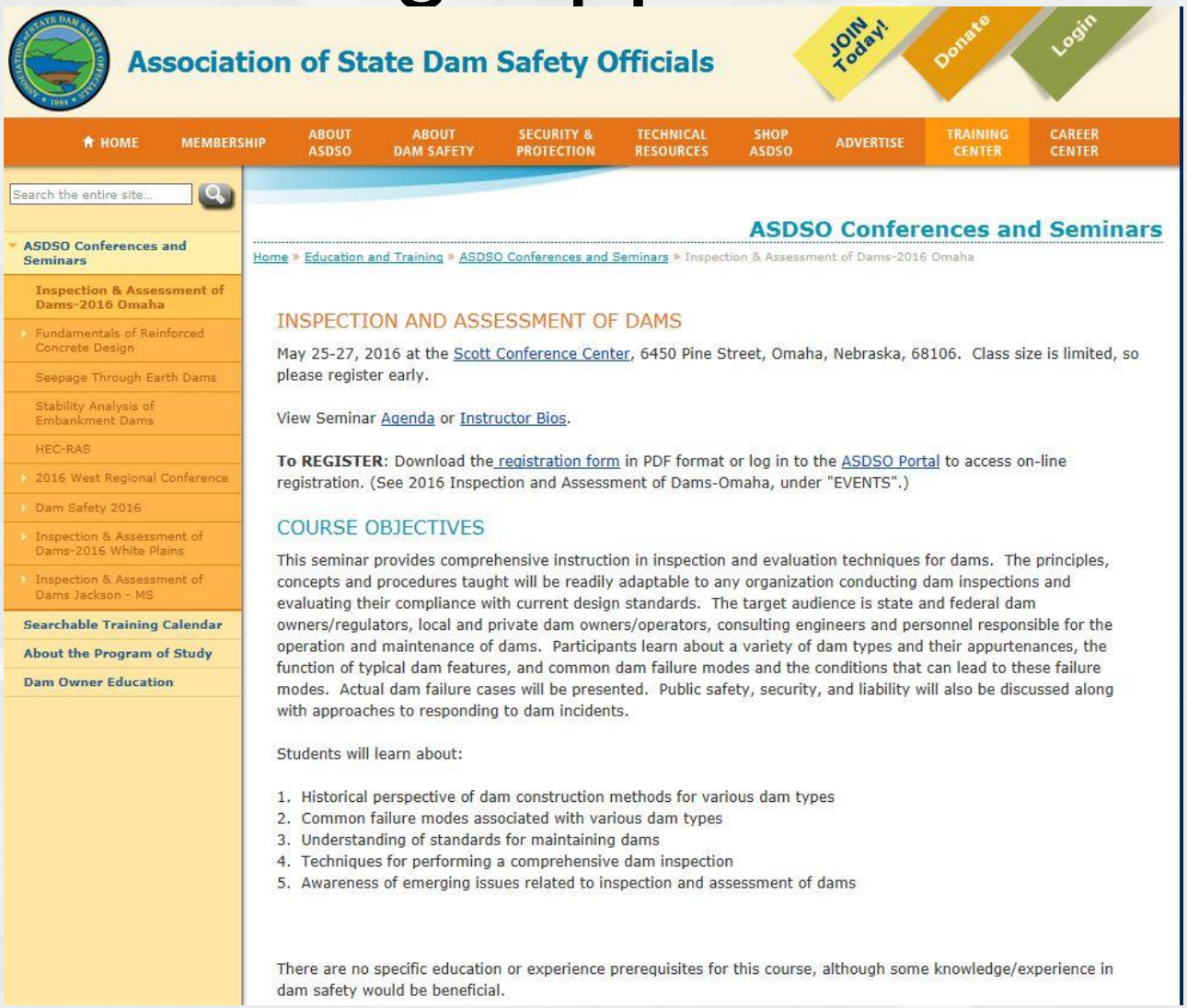
Course Title: Safety Evaluation on Existing Dams (SEED) Seminar (for Domestic Audience)

Target Audience: Federal Employees, Tribal members and Water District Staff affiliated with Bureau of Reclamation projects who are engineers, technicians, operations and maintenance personnel, and administrators responsible for dams.

Course Description: The seminar emphasizes the importance of dam safety and provides information and instruction in dam safety surveillance, including periodic review of pertinent records, visual examination, and monitoring of instrumentation. Hydrologic, seismic and geologic considerations, concrete repair, mechanical equipment, failure modes, remedial measures for dams, and emergency action planning are also discussed. The seminar is suitable for engineers, technicians, maintenance personnel, and administrators responsible for dams.

- http://www.usbr.gov/ssle/damsafety/trn_domestic.html

Training Opportunities



Association of State Dam Safety Officials

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- Stability Analysis of Embankment Dams
- HEC-RAS
- 2016 West Regional Conference
- Dam Safety 2016
- Inspection & Assessment of Dams-2016 White Plains
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Dam Owner Education

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INSPECTION AND ASSESSMENT OF DAMS

May 25-27, 2016 at the Scott Conference Center, 6450 Pine Street, Omaha, Nebraska, 68106. Class size is limited, so please register early.

View Seminar Agenda or Instructor Bios.

To REGISTER: Download the registration form in PDF format or log in to the ASDSO Portal to access on-line registration. (See 2016 Inspection and Assessment of Dams-Omaha, under "EVENTS".)

COURSE OBJECTIVES

This seminar provides comprehensive instruction in inspection and evaluation techniques for dams. The principles, concepts and procedures taught will be readily adaptable to any organization conducting dam inspections and evaluating their compliance with current design standards. The target audience is state and federal dam owners/regulators, local and private dam owners/operators, consulting engineers and personnel responsible for the operation and maintenance of dams. Participants learn about a variety of dam types and their appurtenances, the function of typical dam features, and common dam failure modes and the conditions that can lead to these failure modes. Actual dam failure cases will be presented. Public safety, security, and liability will also be discussed along with approaches to responding to dam incidents.

Students will learn about:

1. Historical perspective of dam construction methods for various dam types
2. Common failure modes associated with various dam types
3. Understanding of standards for maintaining dams
4. Techniques for performing a comprehensive dam inspection
5. Awareness of emerging issues related to inspection and assessment of dams

There are no specific education or experience prerequisites for this course, although some knowledge/experience in dam safety would be beneficial.

- http://www.damsafety.org/conferences/?p=169554c8-0c6c-4b54-8974-1cc280cf527a

Routine Inspections

- Da

Wanapum Dam

Non-Routine Inspections

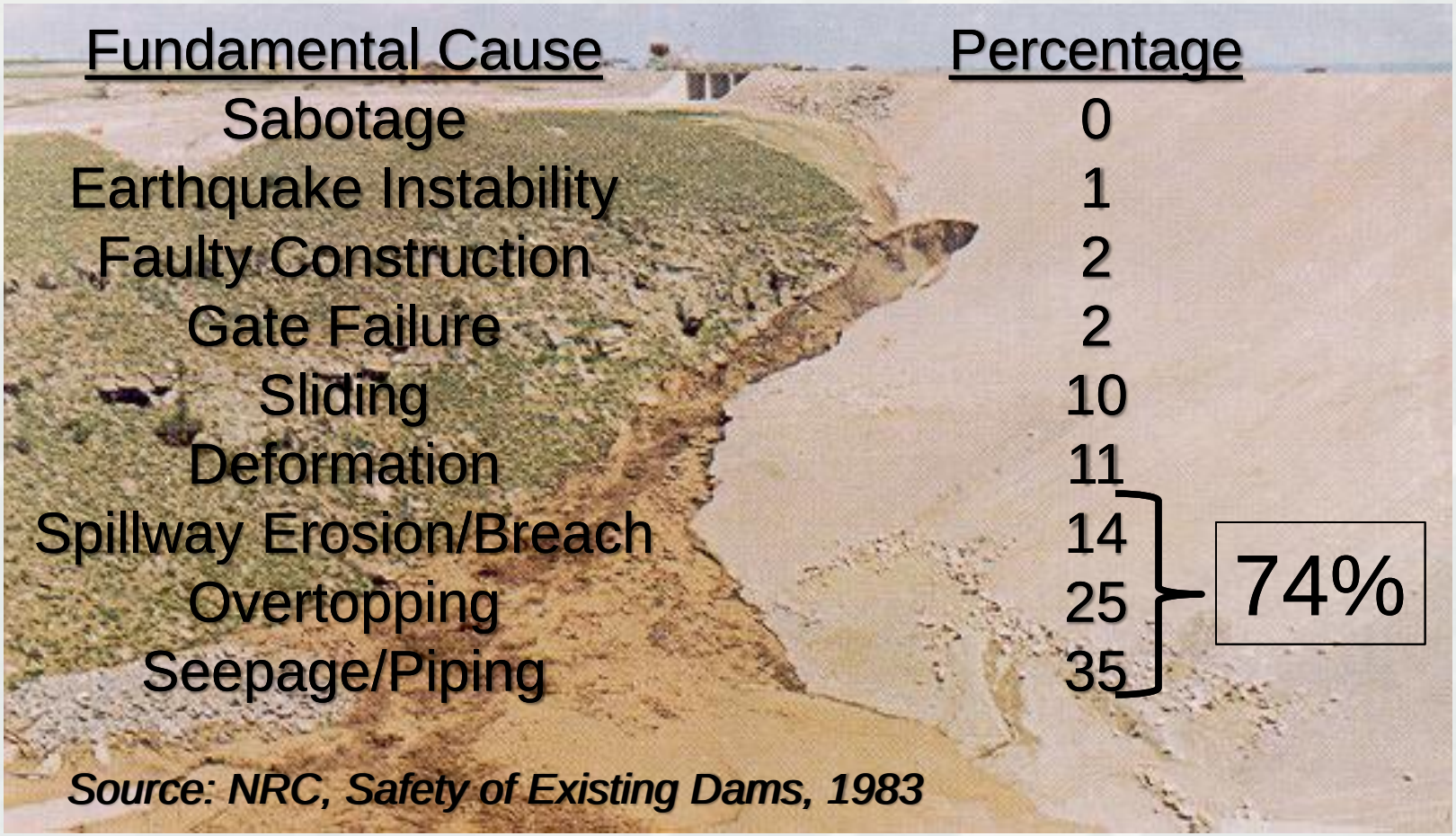
Initiating Events

- Earthquakes
- Floods
- Volcanoes

Initiating Events

- Earthquakes
- Floods
- Volcanoes
- Zombie Apocalypse?

Know Your Failure Modes



Fundamental Cause	Percentage
Sabotage	0
Earthquake Instability	1
Faulty Construction	2
Gate Failure	2
Sliding	10
Deformation	11
Spillway Erosion/Breach	14
Overtopping	25
Seepage/Piping	35

74%

Source: NRC, Safety of Existing Dams, 1983

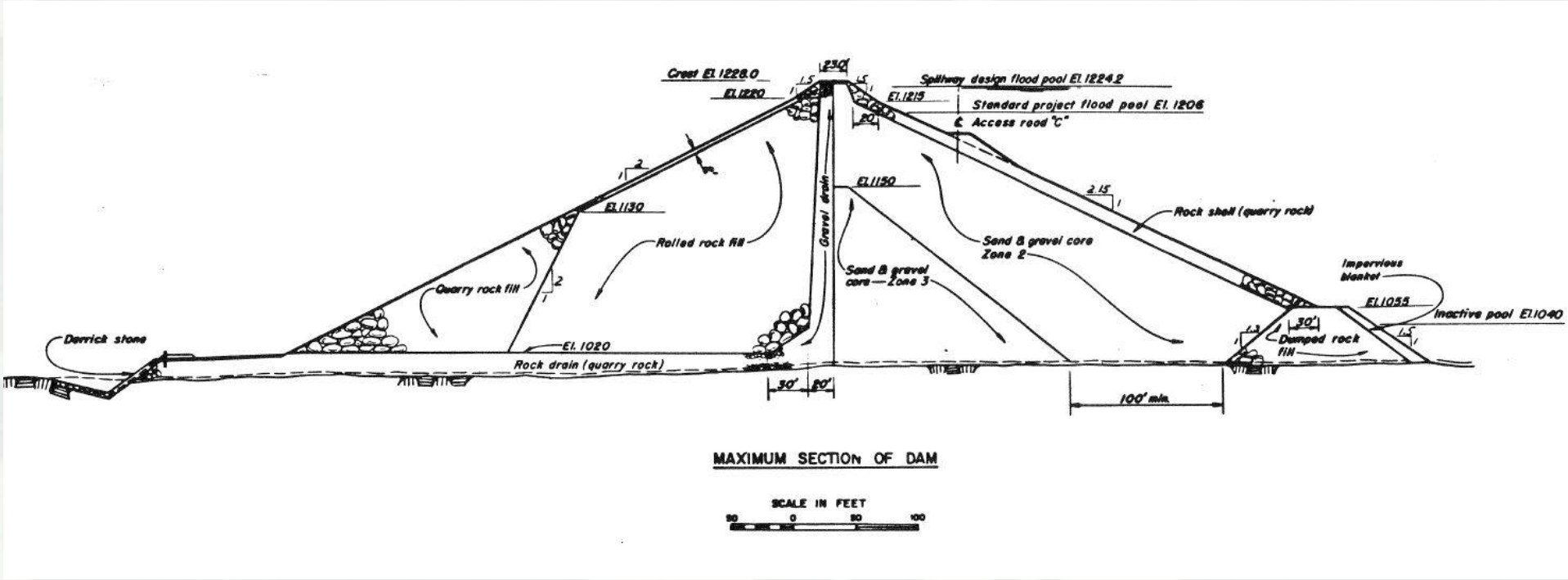
Floods

Visual Symptoms of Distress

Interpreting Instrumentation

Example: Howard A. Hanson Dam

Build a Model



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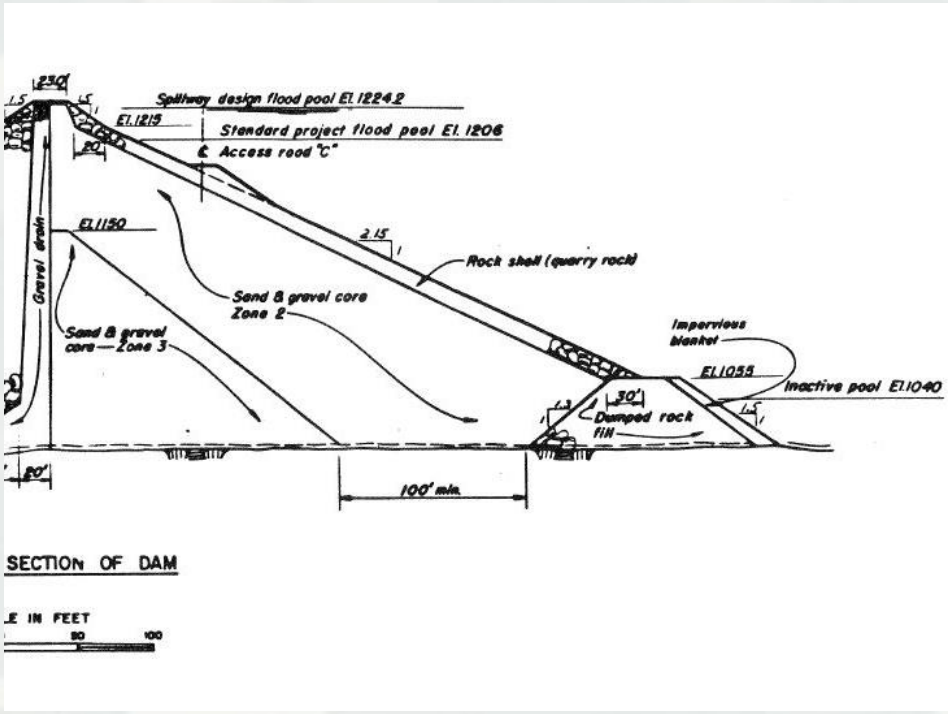

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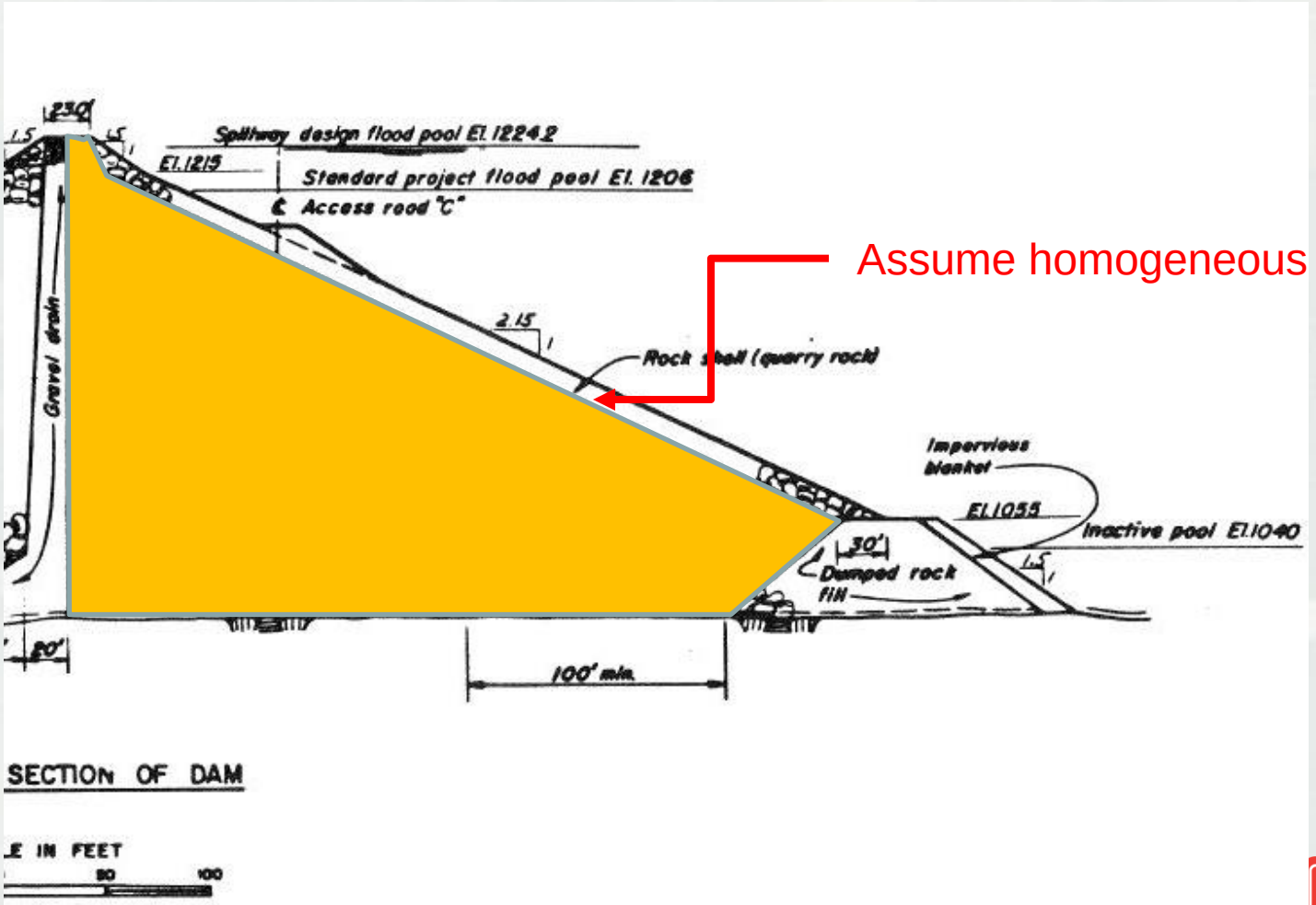
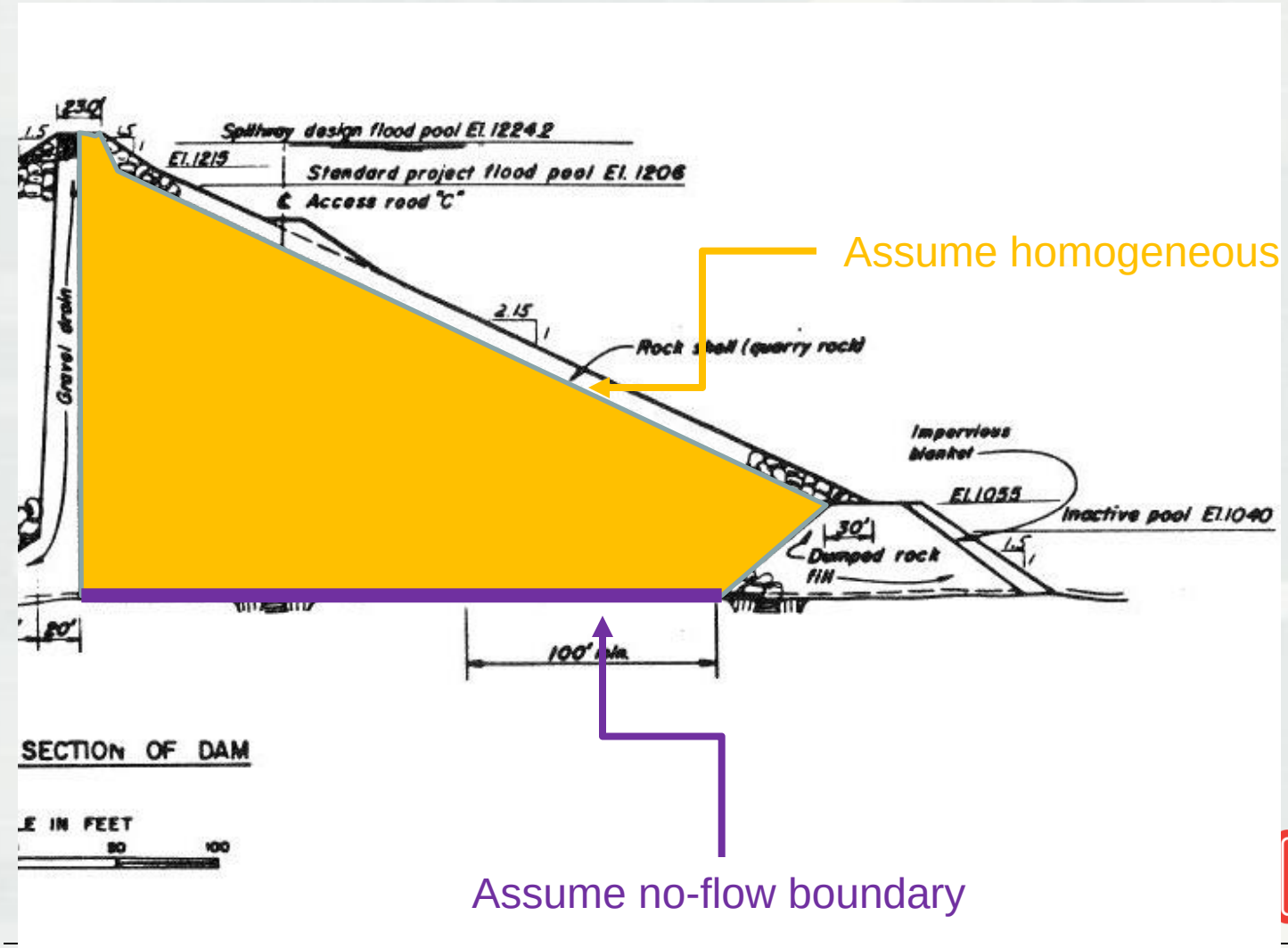


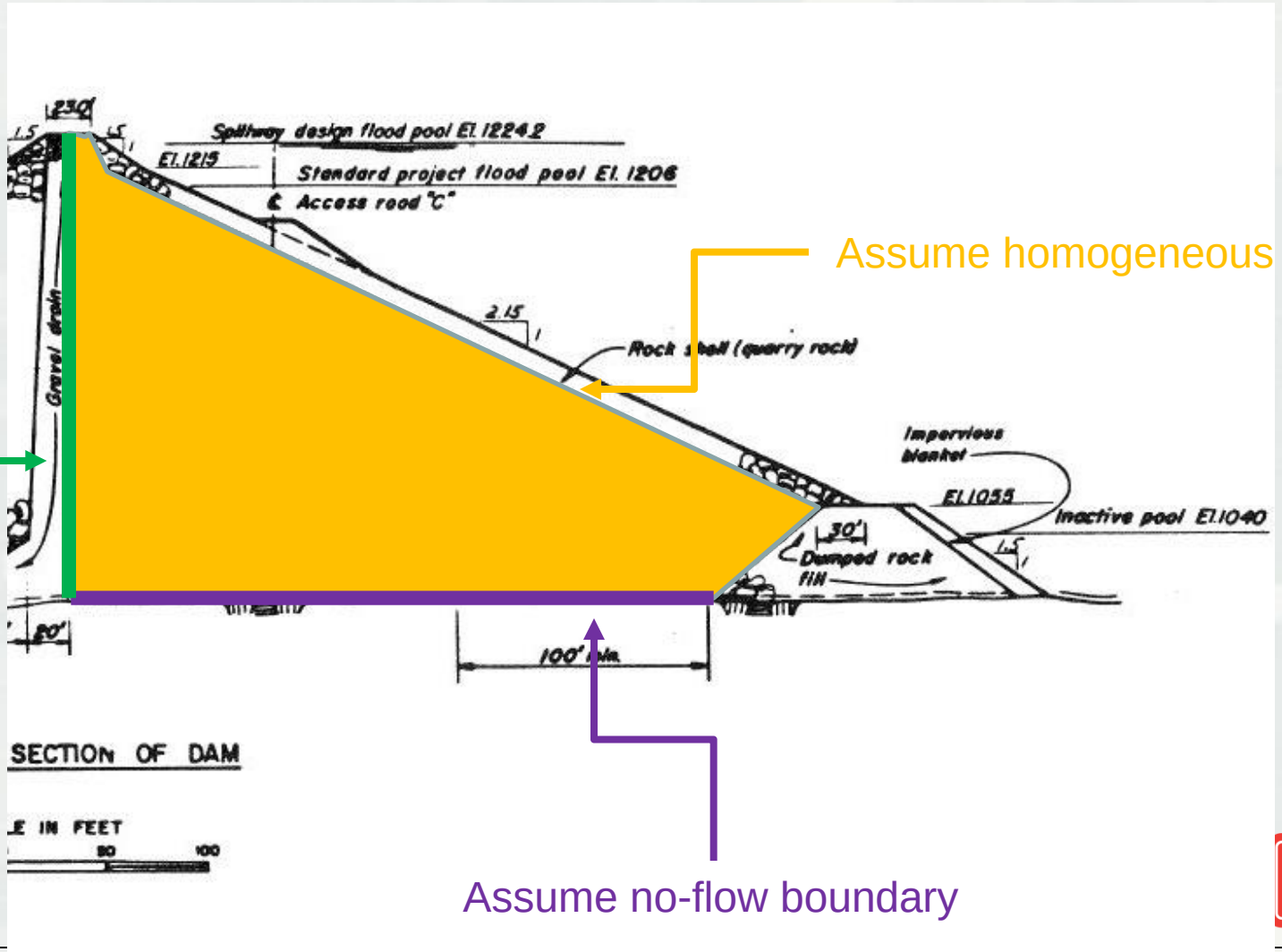
Assume homogeneous

Build a Model



Build a Model

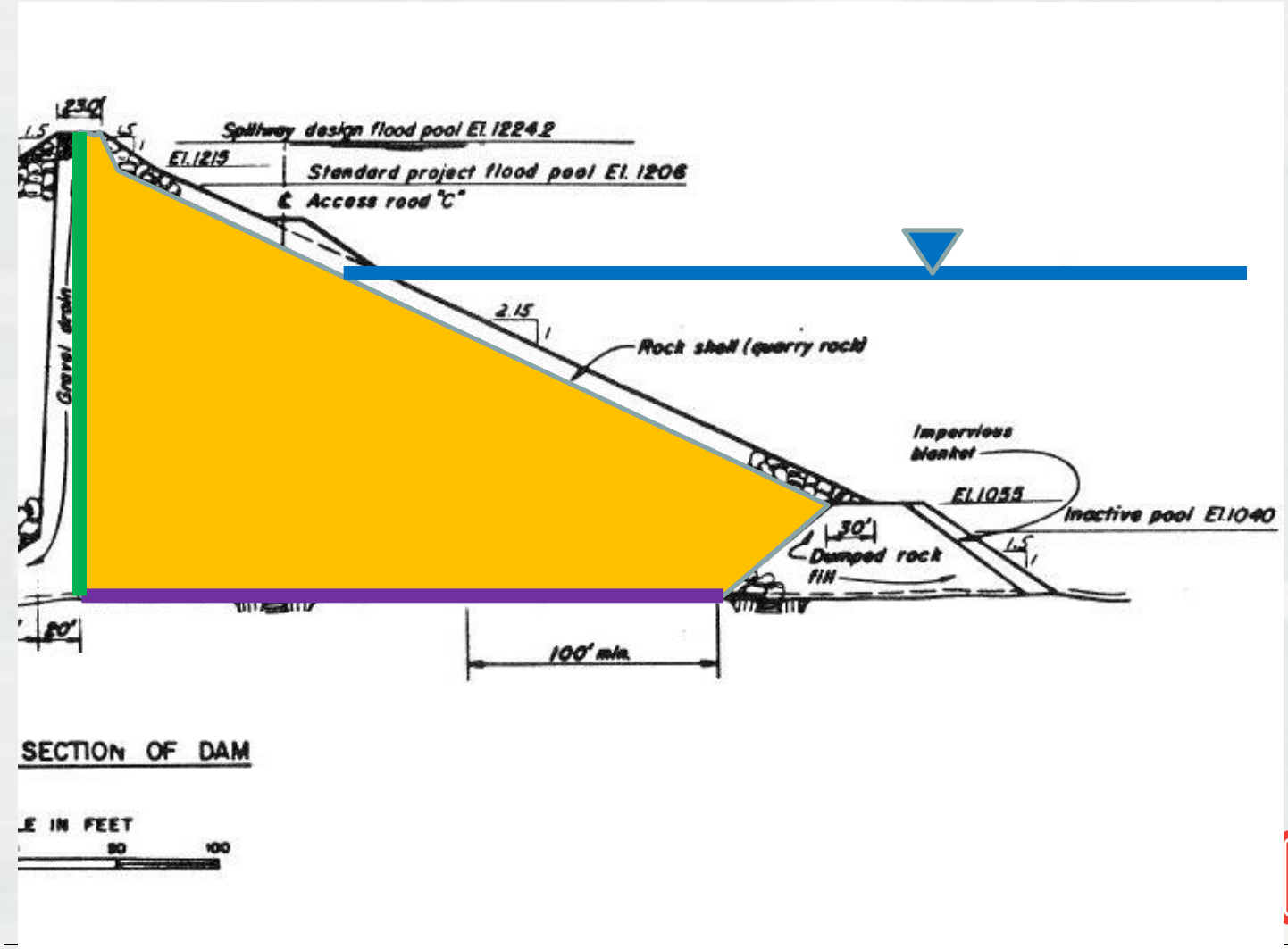
Assume no-head boundary



Assume homogeneous

Assume no-flow boundary

Build a Model



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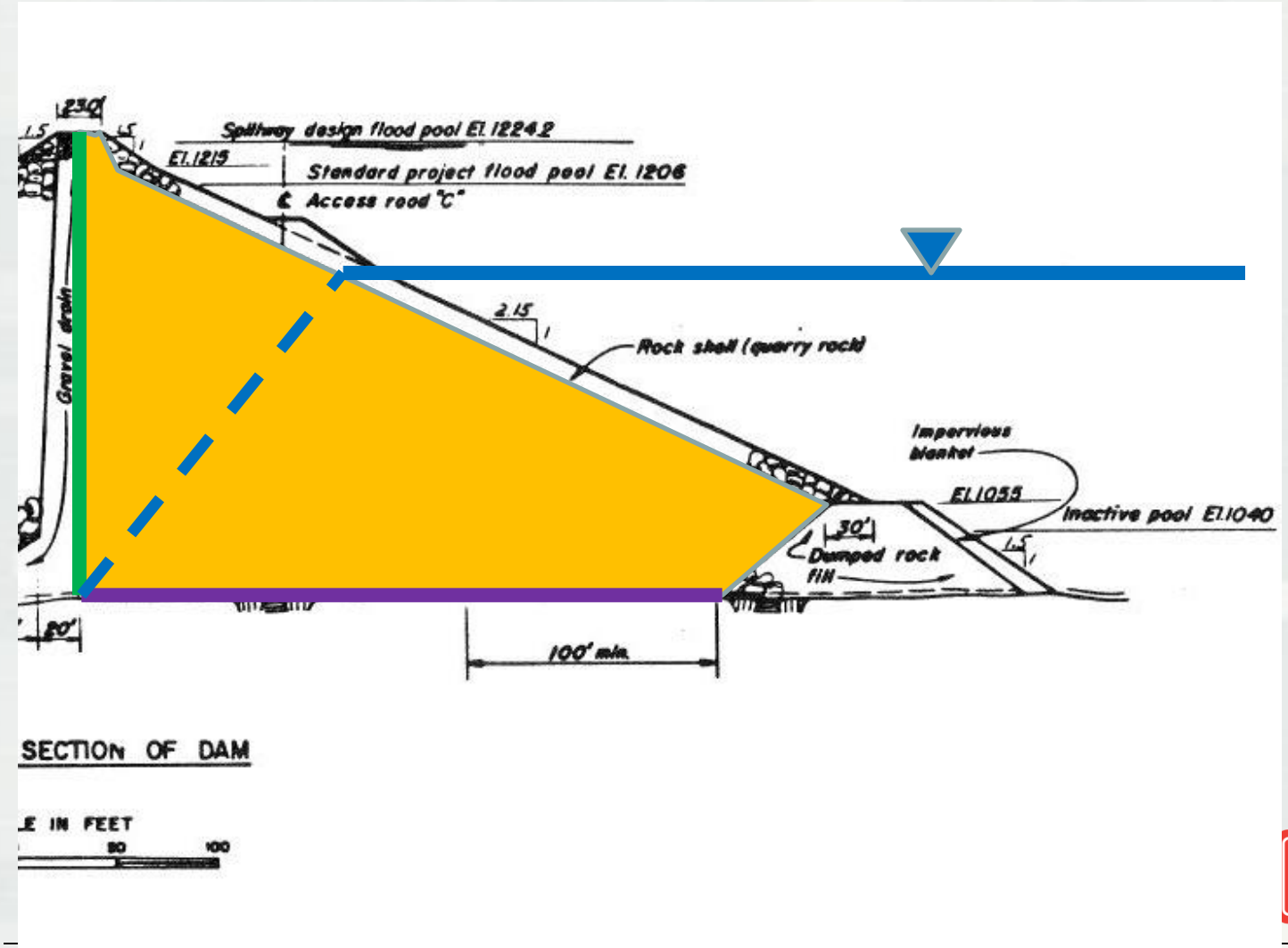

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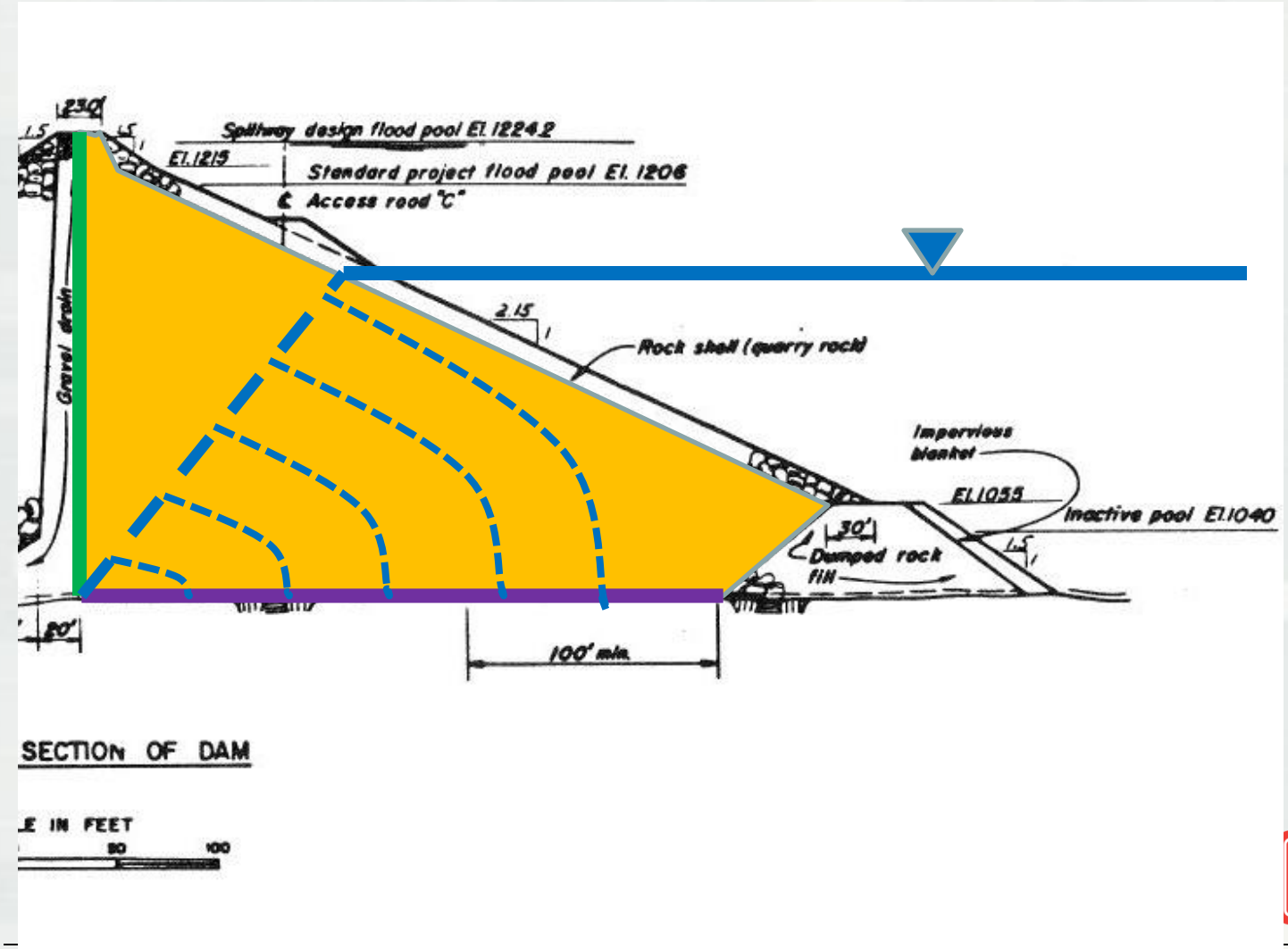

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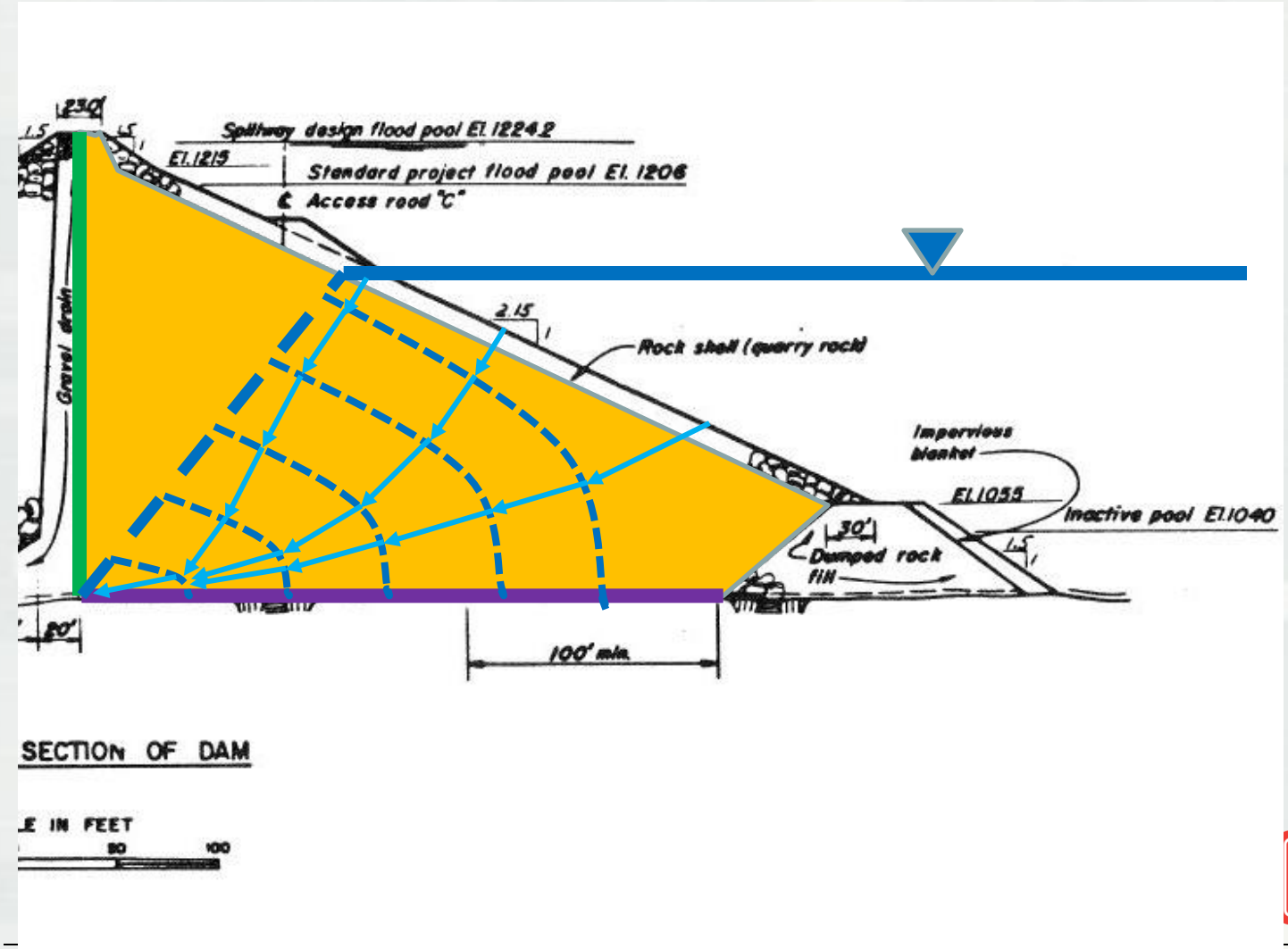

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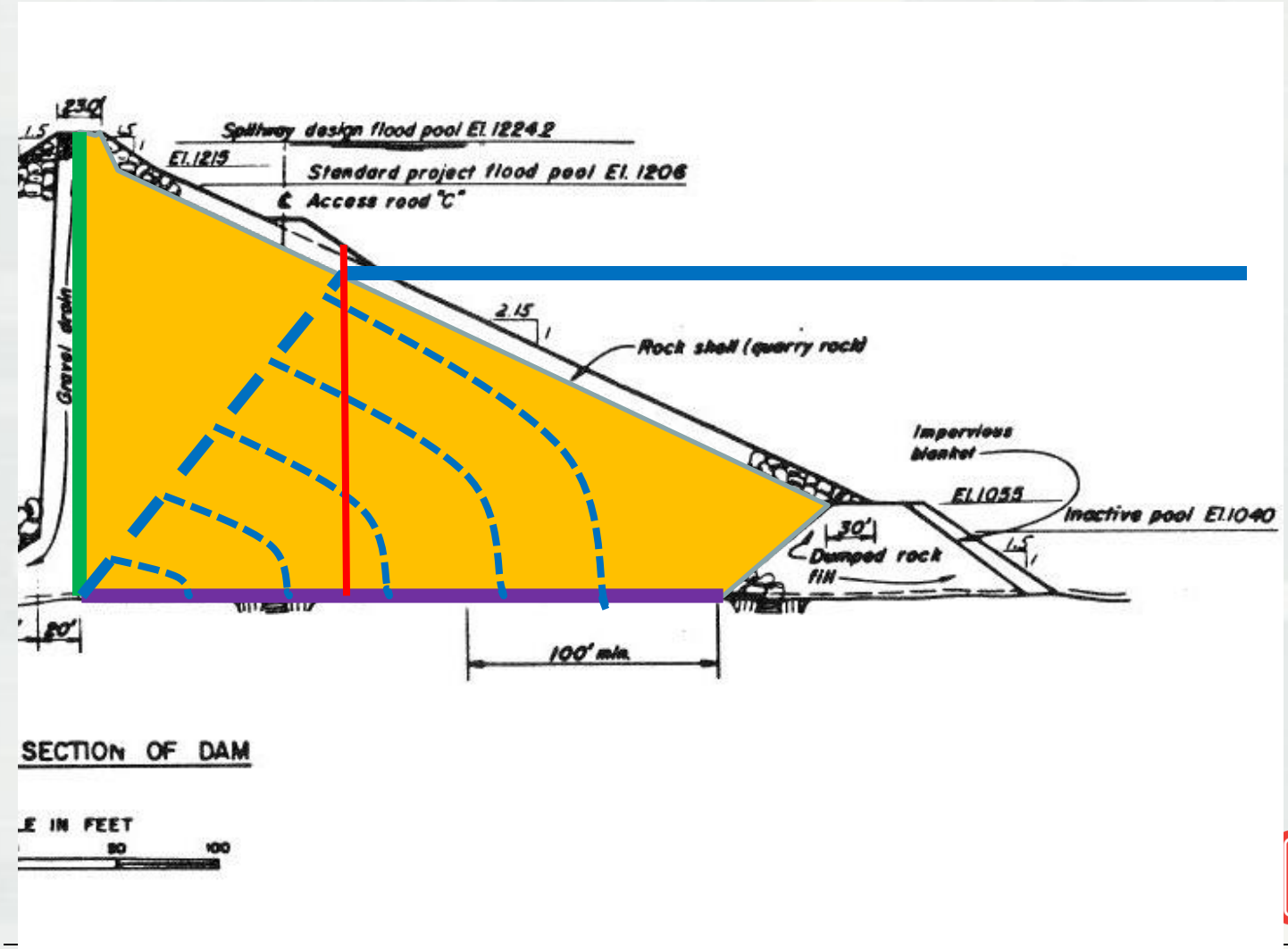

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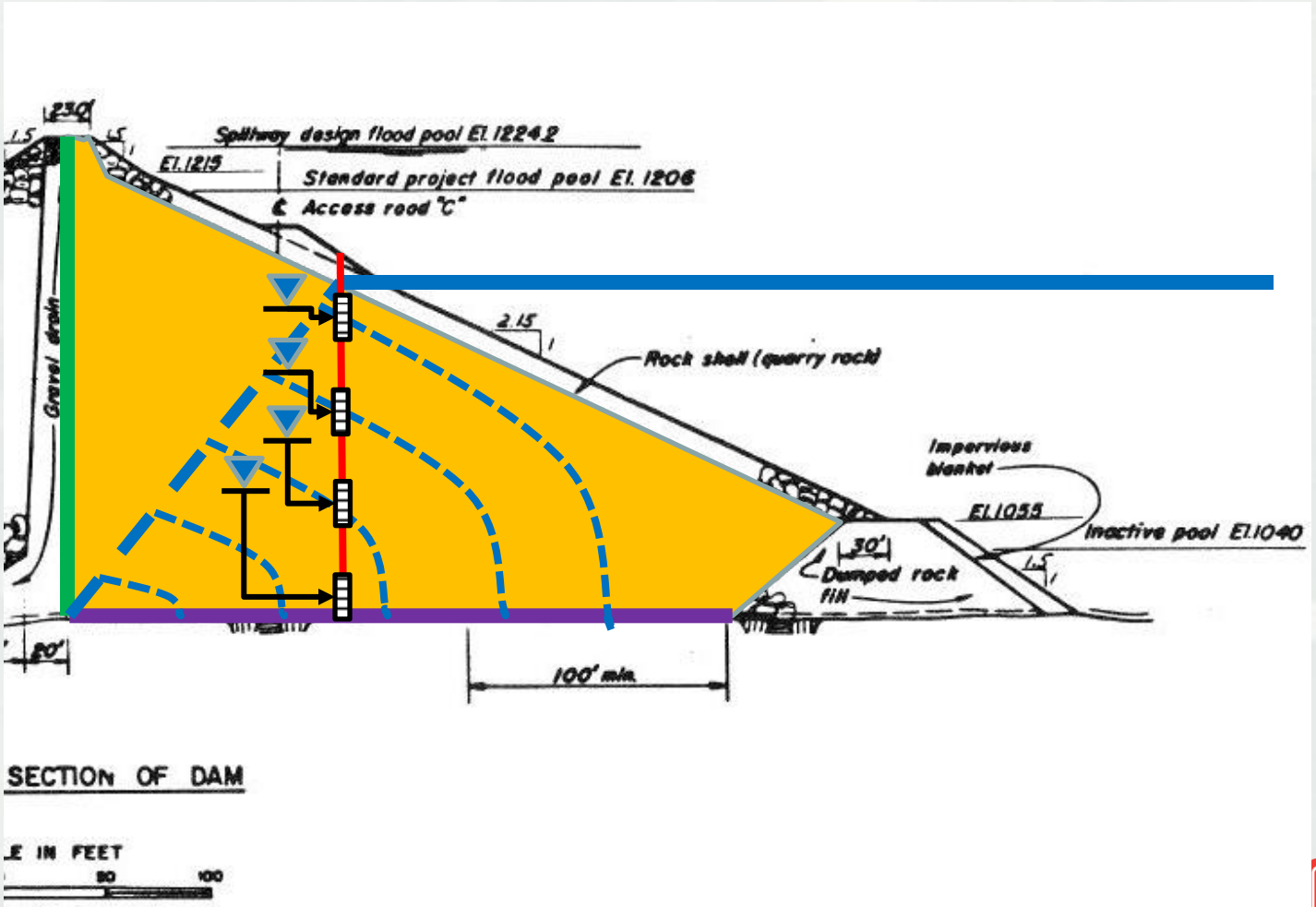
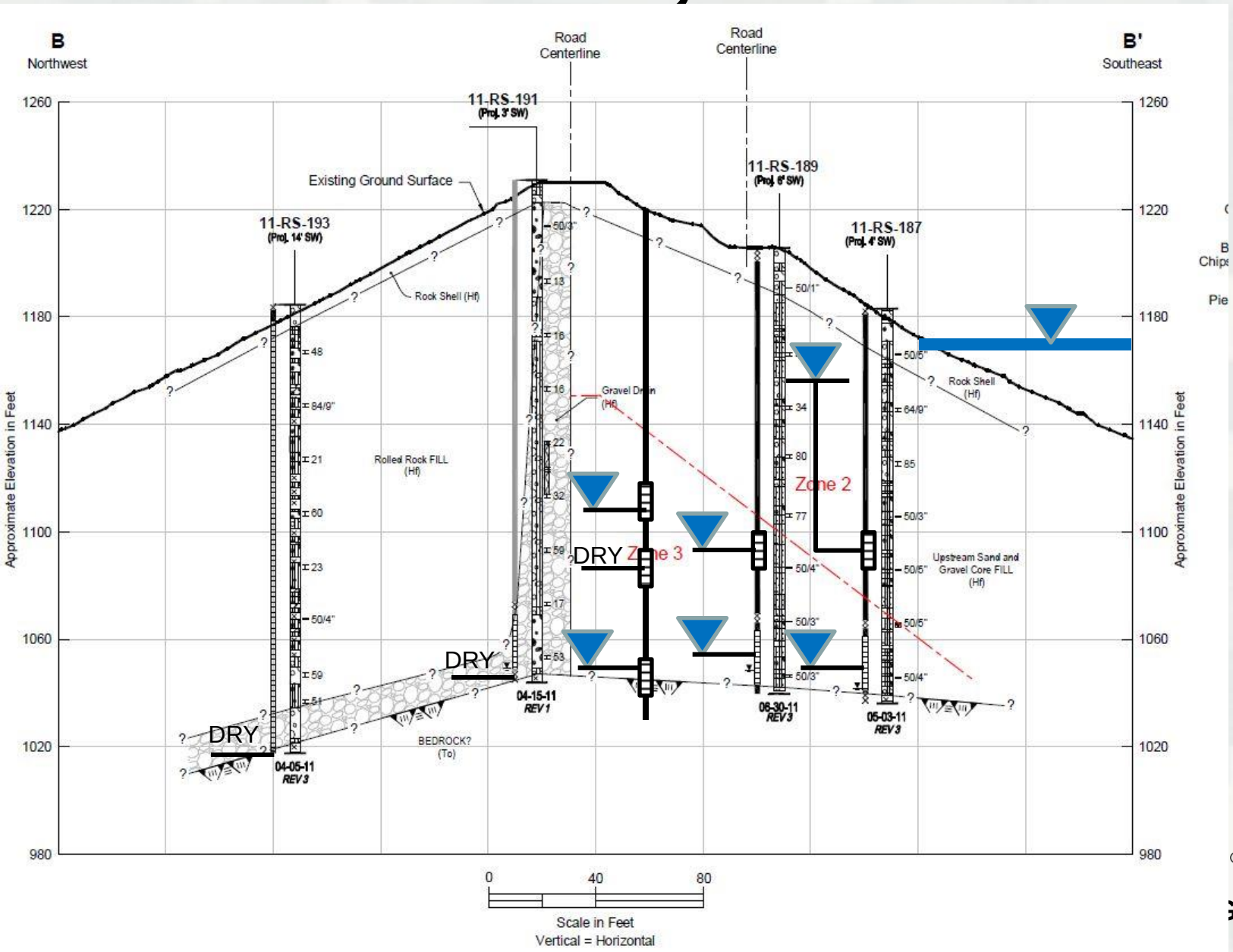
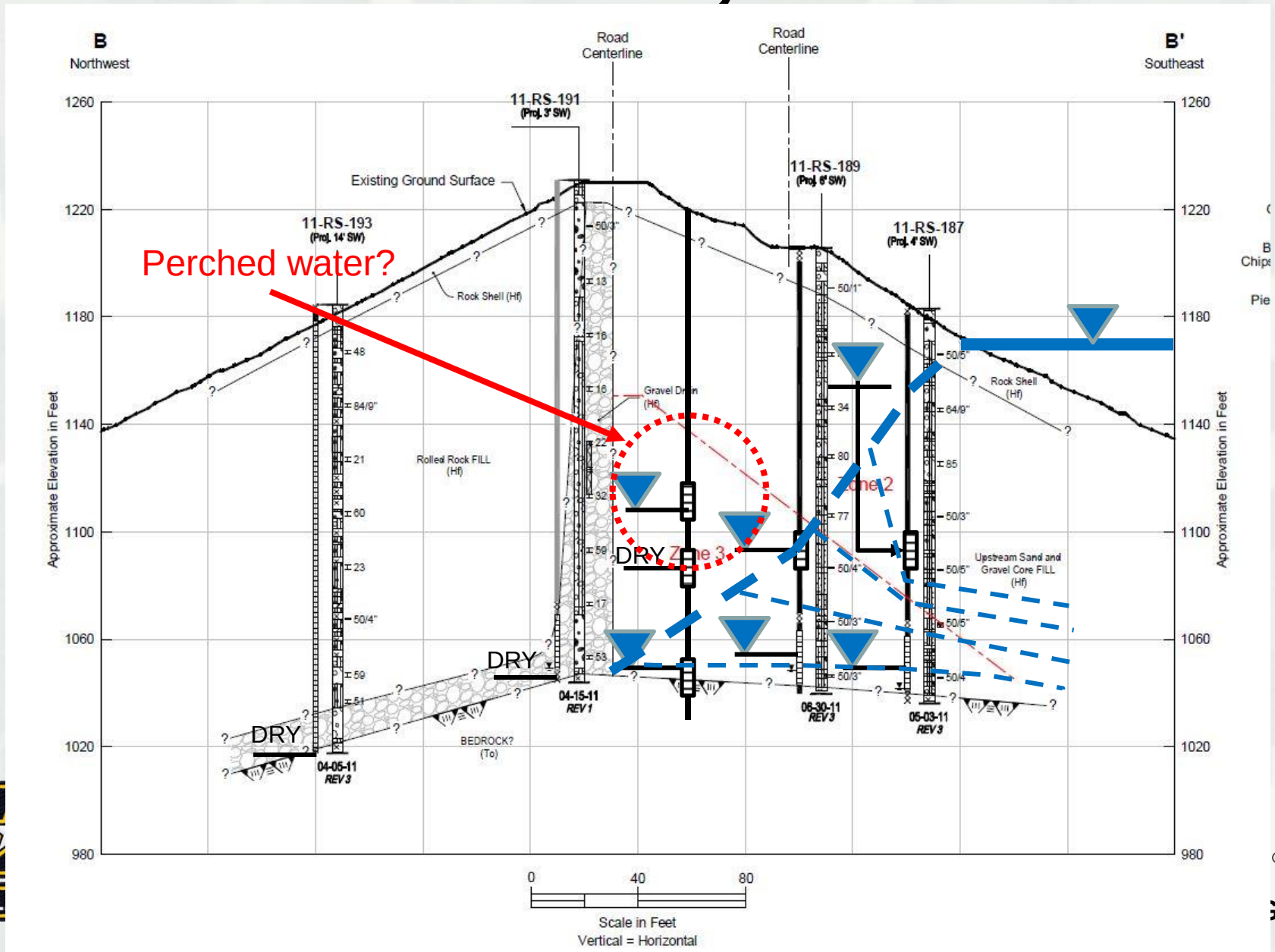


Reality


B
Northwest
B'
Southeast
Road Centerline
Road Centerline
11-RS-191
(Proj. 3' SW)
11-RS-189
(Proj. 6' SW)
11-RS-187
(Proj. 4' SW)
11-RS-193
(Proj. 14' SW)
Existing Ground Surface
Rock Shell (Hf)
Rolled Rock FILL (Hf)
Gravel Drain (Hf)
Zone 2
DRY
DRY
Upstream Sand and Gravel Core FILL (Hf)
BEDROCK? (To)
04-05-11 REV 3
04-15-11 REV 1
06-30-11 REV 3
05-03-11 REV 3
Approximate Elevation in Feet
1260
1220
1180
1140
1100
1060
1020
980
0
40
80
Scale in Feet
Vertical = Horizontal

Reality


B
Northwest
B'
Southeast
Road Centerline
Road Centerline
11-RS-191
(Proj. 3' SW)
11-RS-189
(Proj. 6' SW)
11-RS-187
(Proj. 4' SW)
11-RS-193
(Proj. 14' SW)
Existing Ground Surface
Perched water?
Rock Shell (Hf)
Rolled Rock FILL (Hf)
Gravel Drain (Hf)
Rock Shell (Hf)
Upstream Sand and Gravel Core FILL (Hf)
DRY
DRY
DRY
BEDROCK? (To)
04-05-11 REV 3
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Approximate Elevation in Feet
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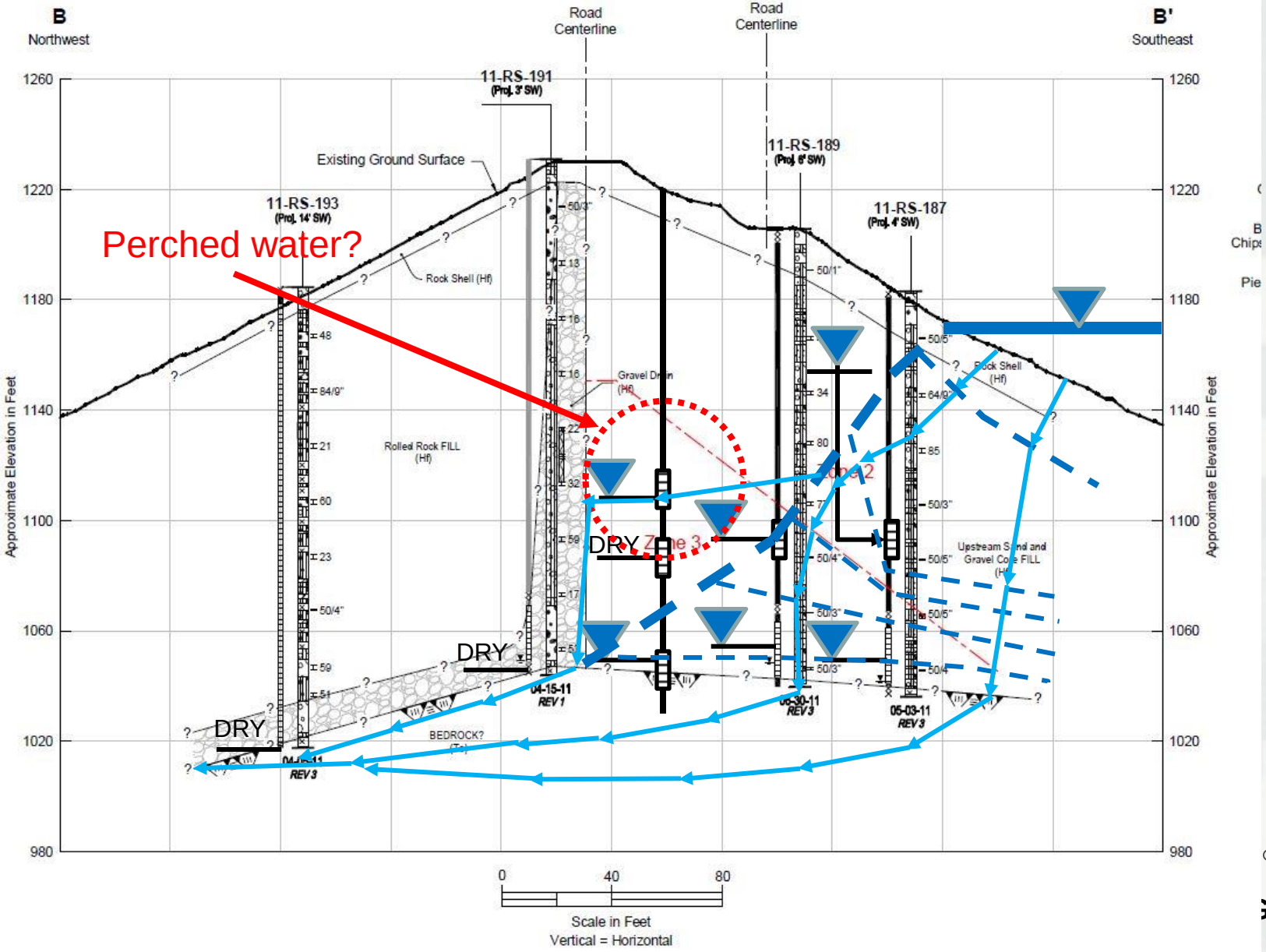
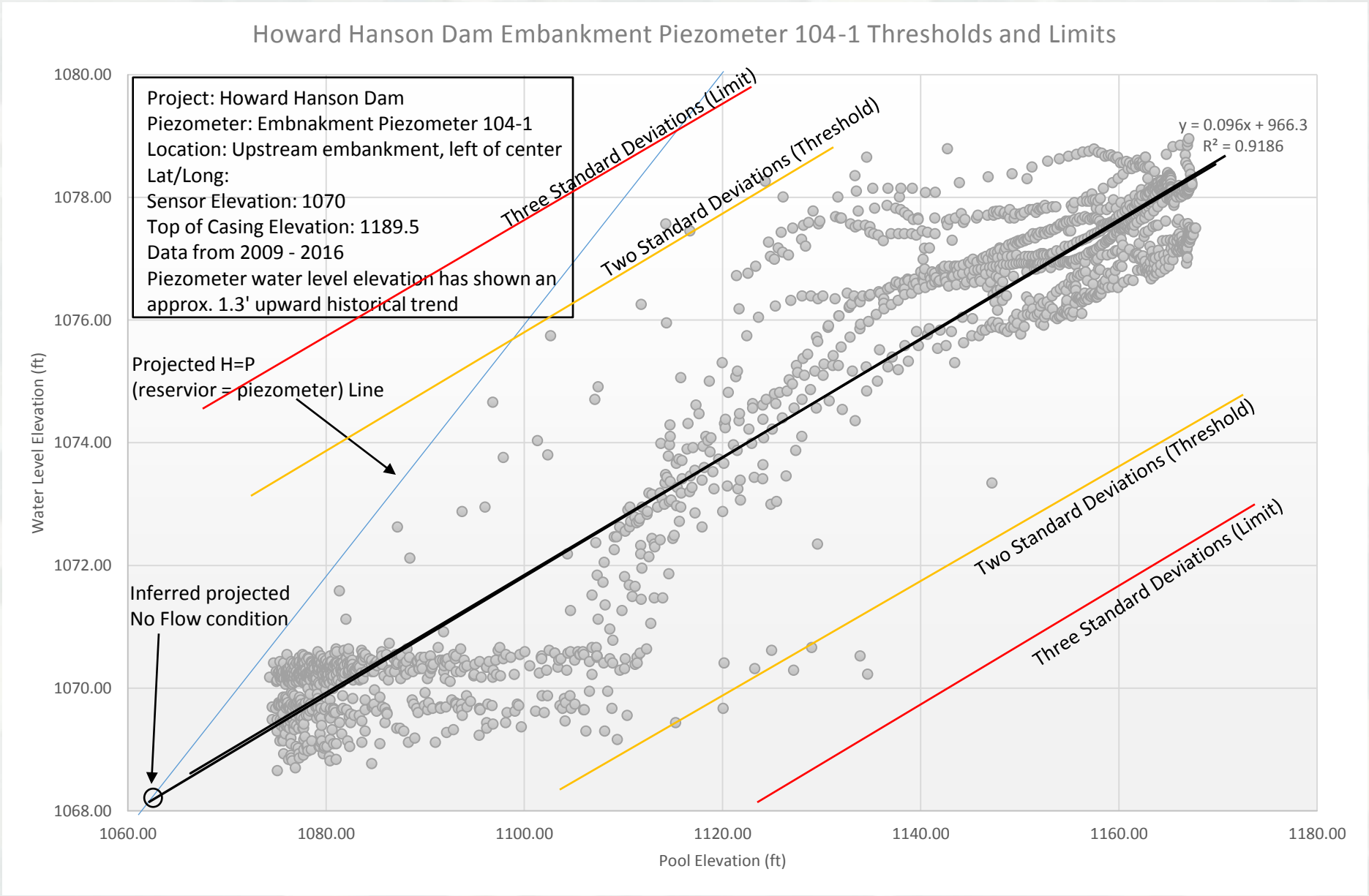
1220
1180
1140
1100
1060
1020
980
0
40
80
Scale in Feet
Vertical = Horizontal

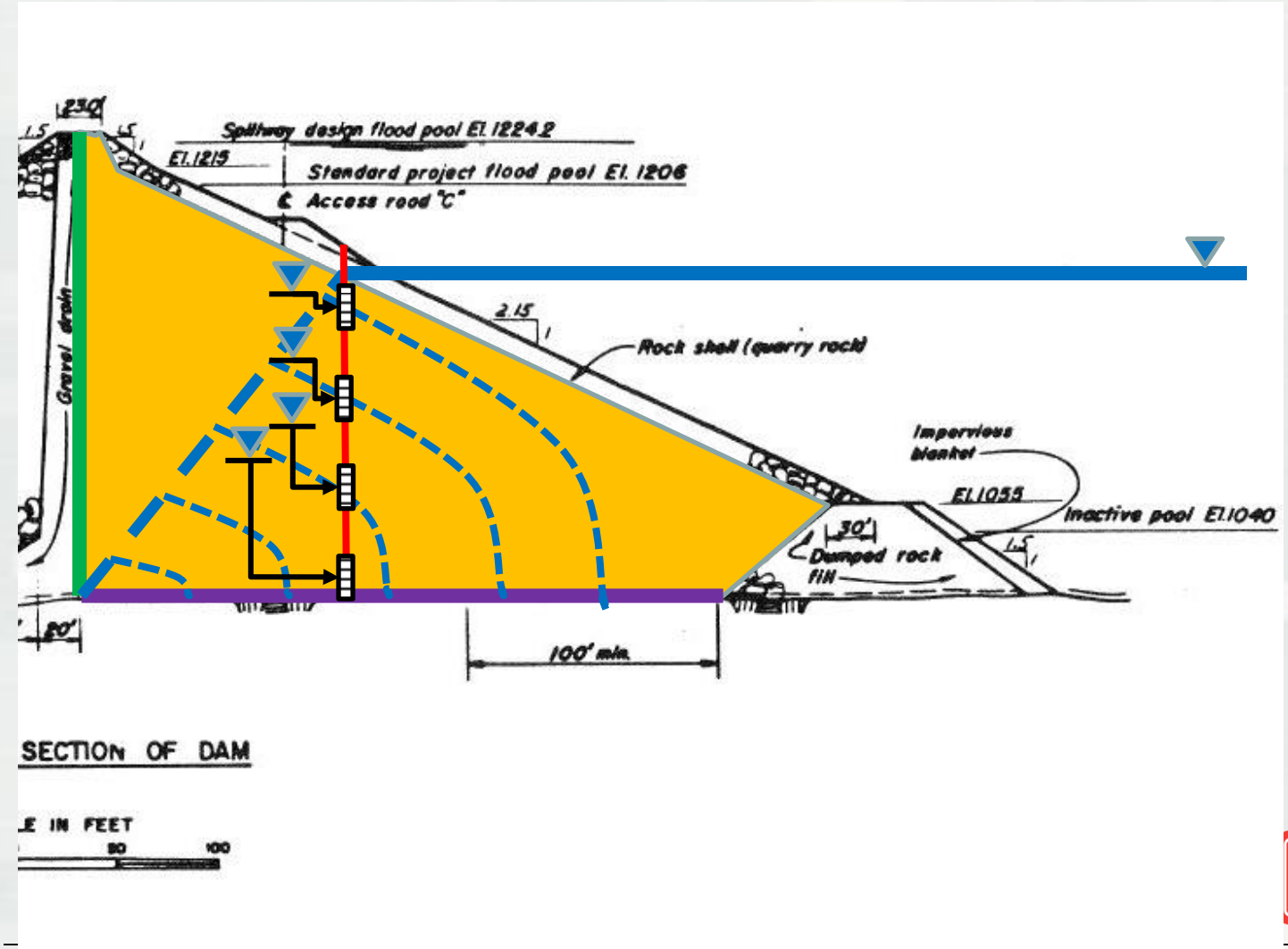
Reality


B
Northwest
B'
Southeast
Road Centerline
Road Centerline
11-RS-191
(Proj. 3' SW)
11-RS-189
(Proj. 6' SW)
11-RS-187
(Proj. 4' SW)
11-RS-193
(Proj. 14' SW)
Existing Ground Surface
Perched water?
Rock Shell (Rf)
Rolled Rock FILL (Rf)
Gravel Drain (Rf)
Rock Shell (Rf)
Upstream Sand and Gravel Core FILL (Rf)
DRY
DRY
DRY
Zone 2
Zone 3
BEDROCK?
04-15-11 REV 1
05-03-11 REV 3
Approximate Elevation in Feet
1260
1220
1180
1140
1100
1060
1020
980
0
40
80
Scale in Feet
Vertical = Horizontal

Trends

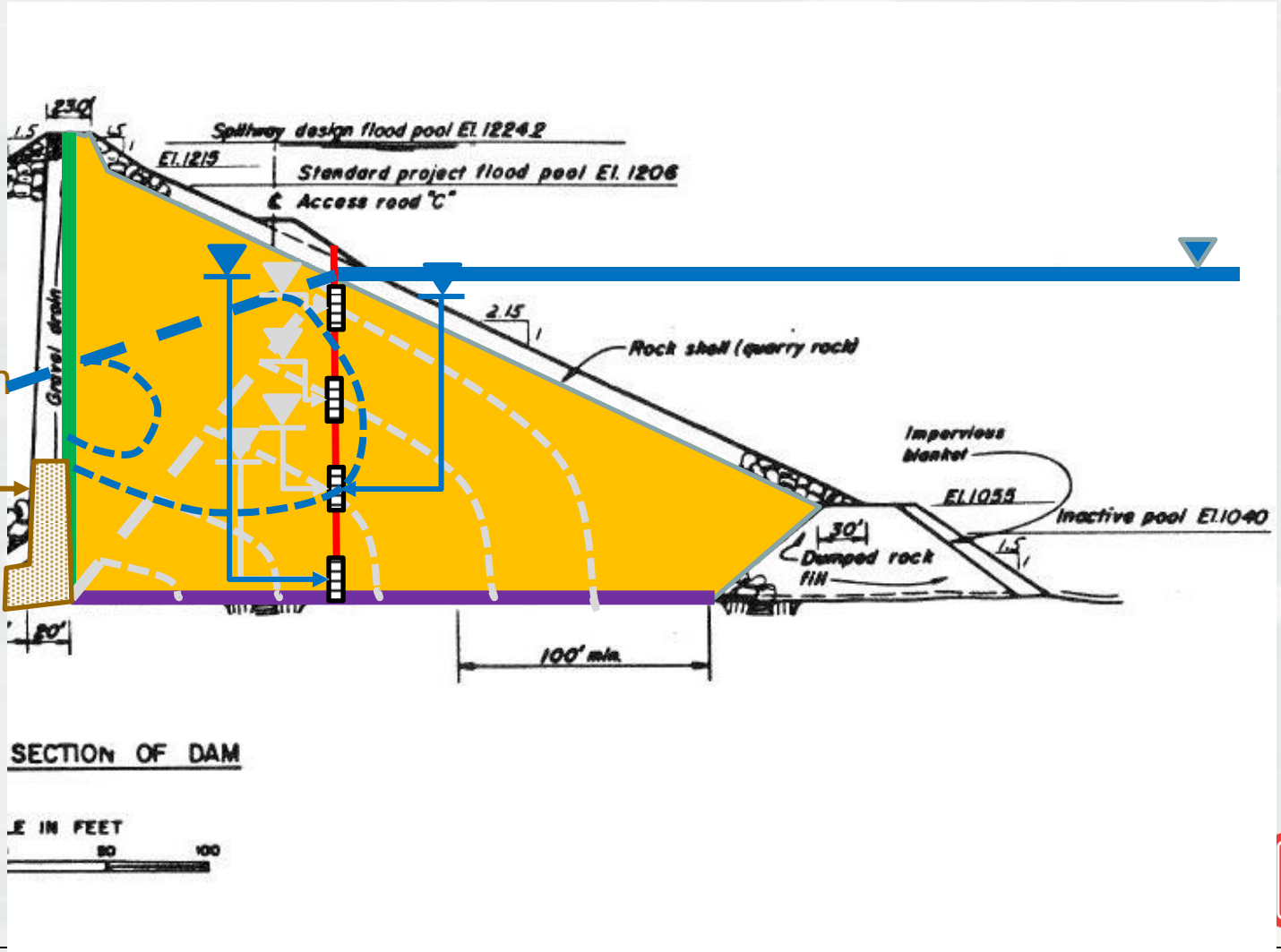

Howard Hanson Dam Embankment Piezometer 104-1 Thresholds and Limits
Project: Howard Hanson Dam
Piezometer: Embnakment Piezometer 104-1
Location: Upstream embankment, left of center
Lat/Long:
Sensor Elevation: 1070
Top of Casing Elevation: 1189.5
Data from 2009 - 2016
Piezometer water level elevation has shown an approx. 1.3' upward historical trend
Three Standard Deviations (Limit)
Two Standard Deviations (Threshold)
y = 0.096x + 966.3
R² = 0.9186
Projected H=P
(reservior = piezometer) Line
Inferred projected
No Flow condition
Two Standard Deviations (Threshold)
Three Standard Deviations (Limit)
Water Level Elevation (ft)
1080.00
1078.00
1076.00
1074.00
1072.00
1070.00
1068.00
1060.00
1080.00
1100.00
1120.00
1140.00
1160.00
1180.00
Pool Elevation (ft)

Non-Failure Model



Failure Model: Drain Plugging

Fines plug gravel drain



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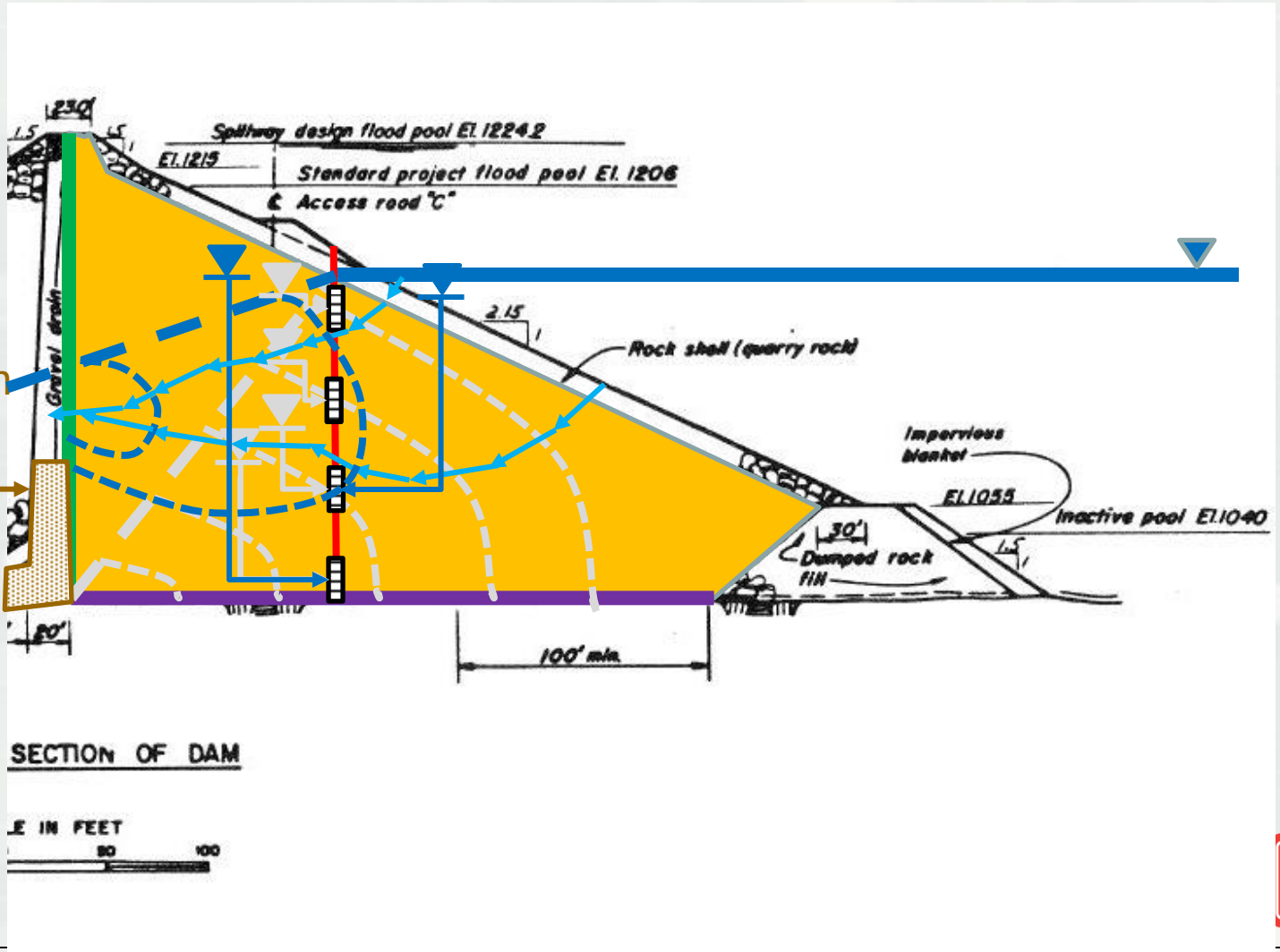
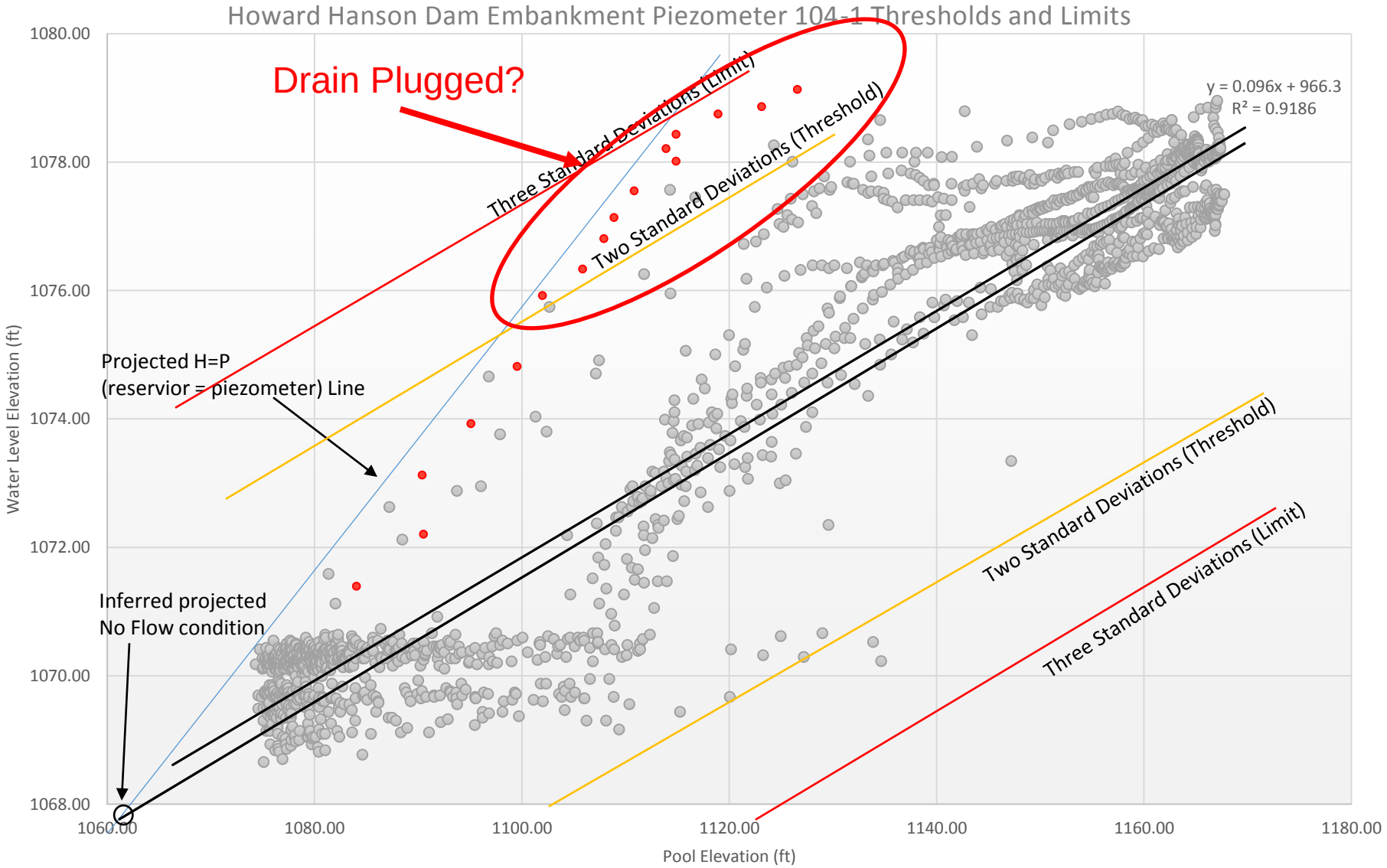
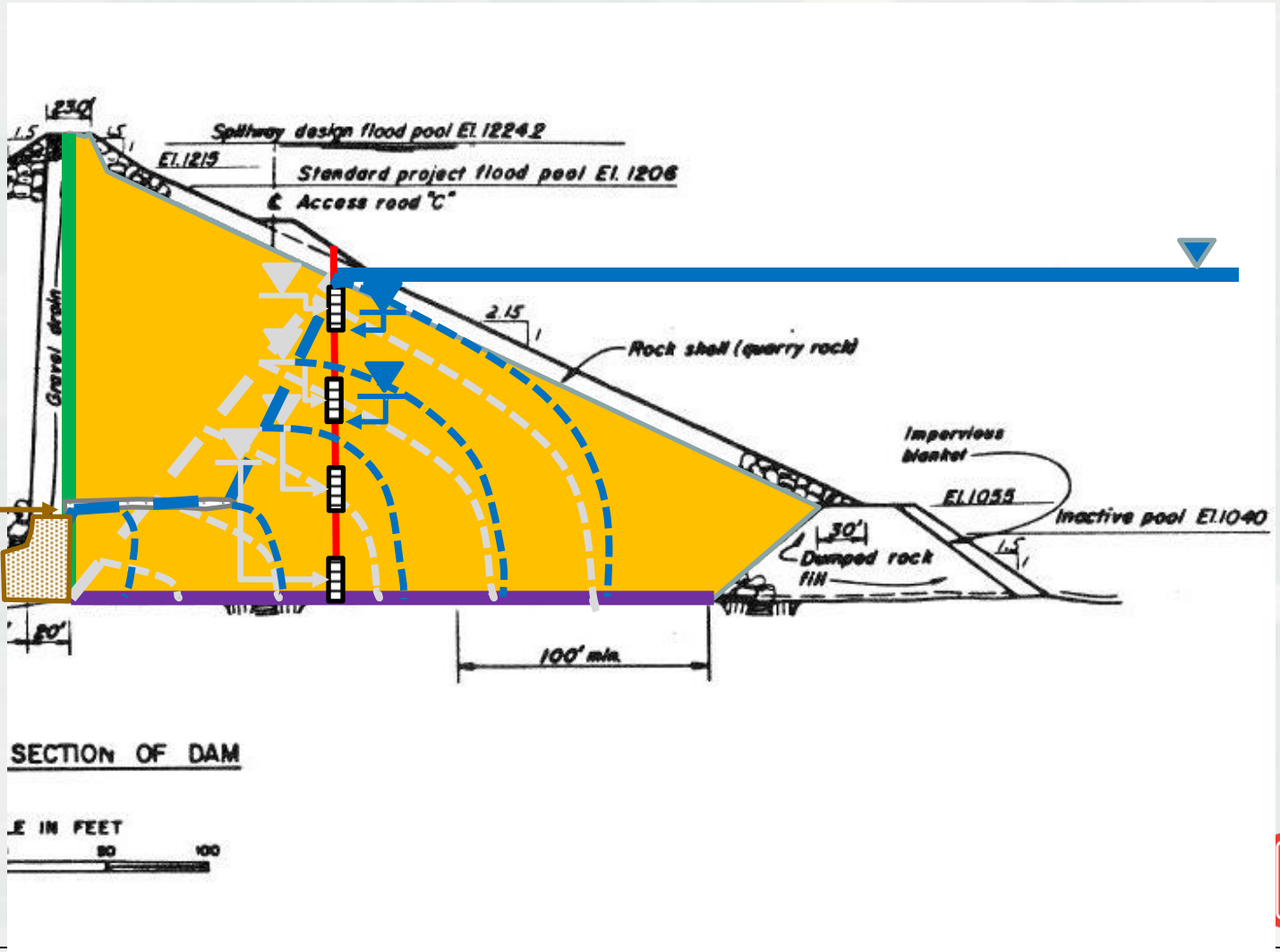


Failure Trends



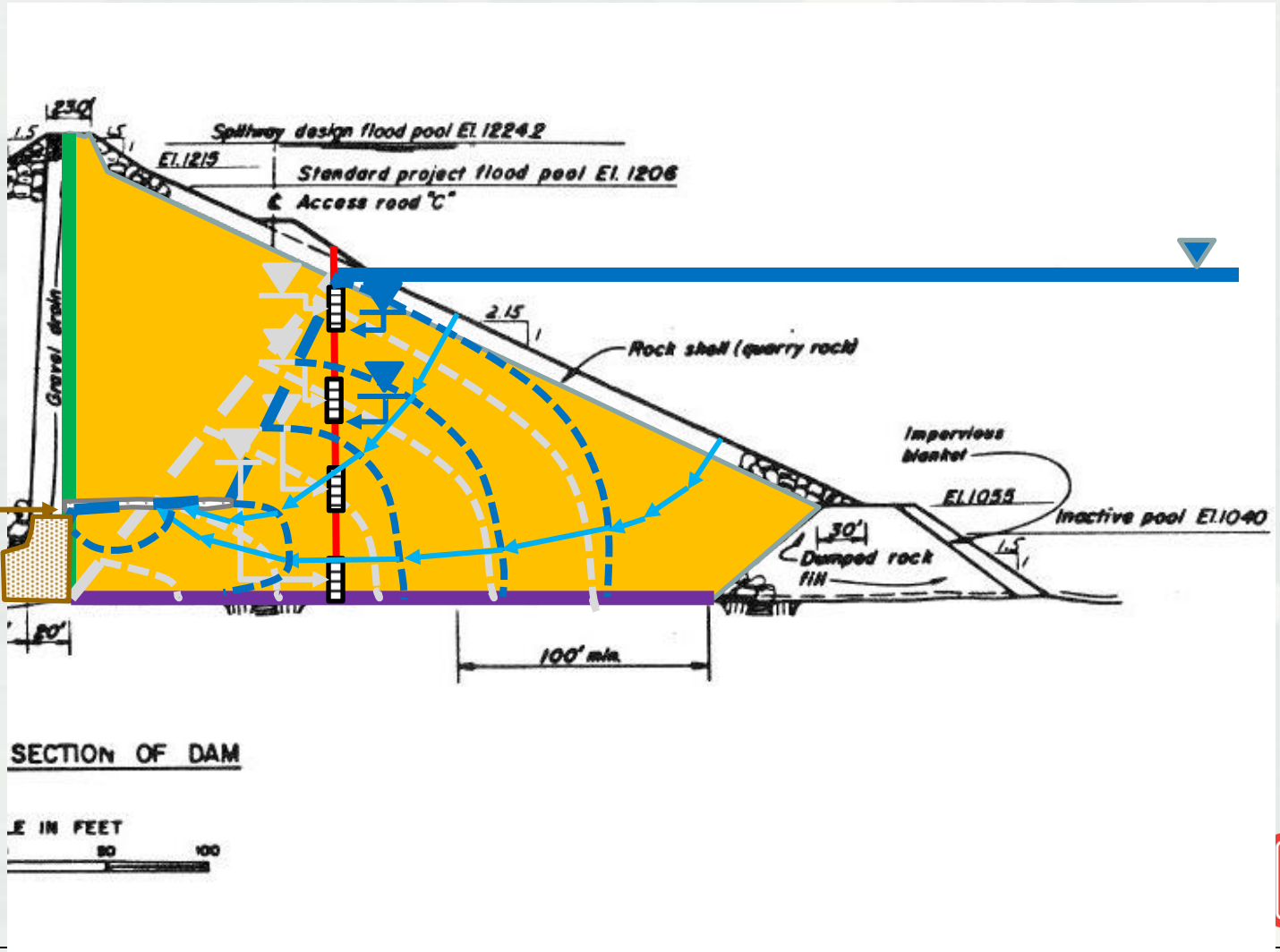
Failure Model: Piping

Pipe connected to drain

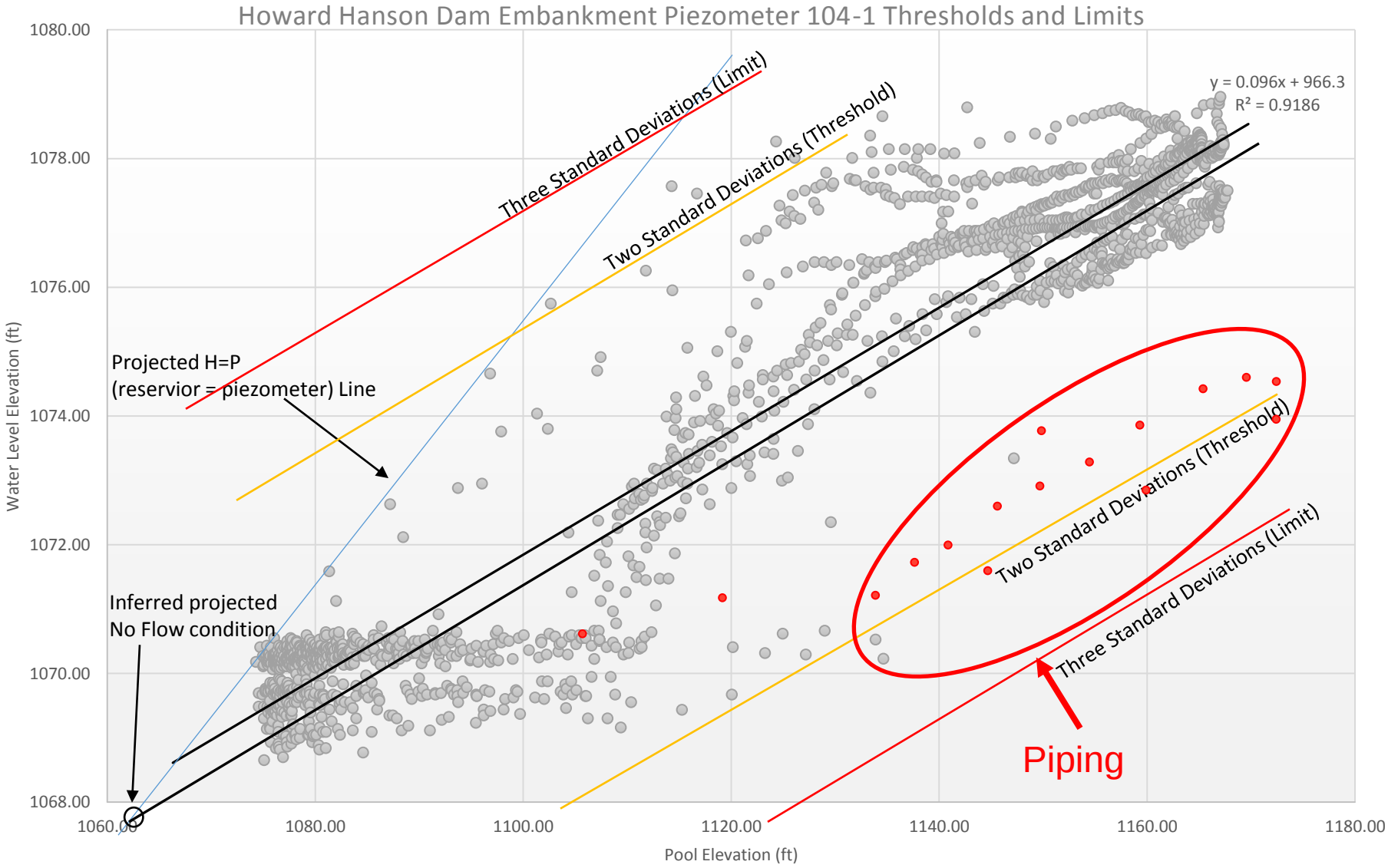


Failure Model: Piping

Pipe connected to drain



Failure Trends



Spill Event Example

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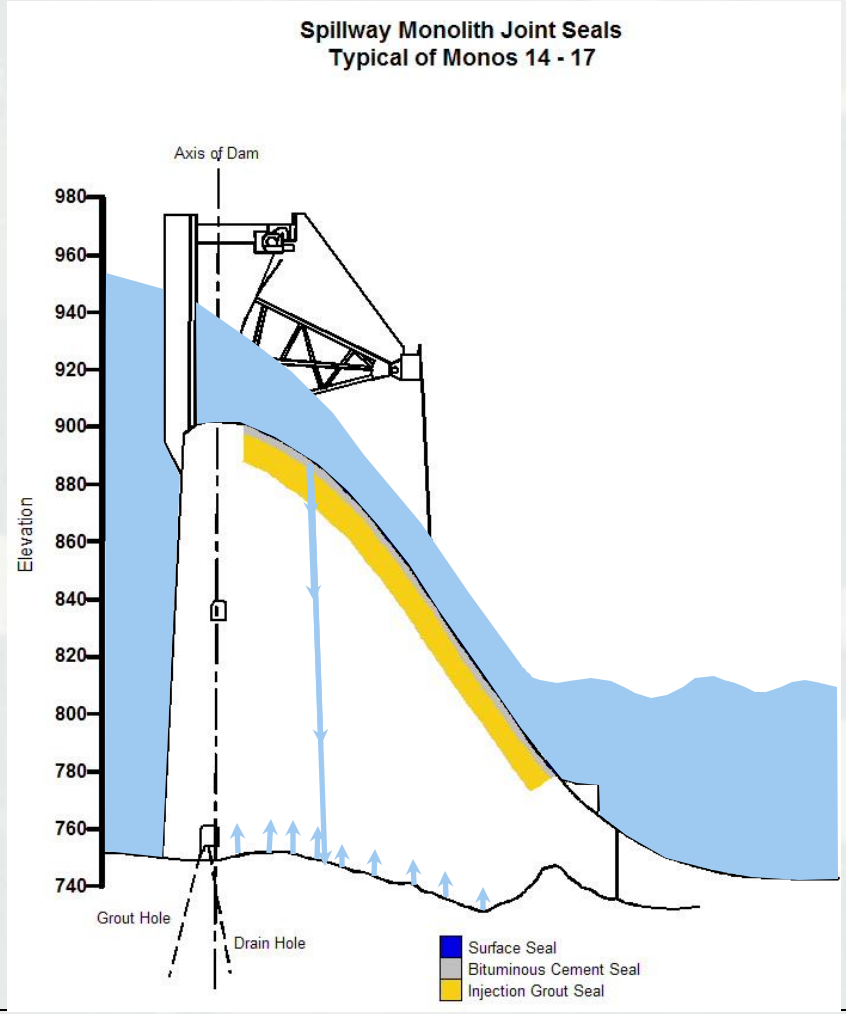
Failure Model – Spill Induced Uplift



Setting Thresholds & Limits

Uplift Pressures[1]:

Threshold values:

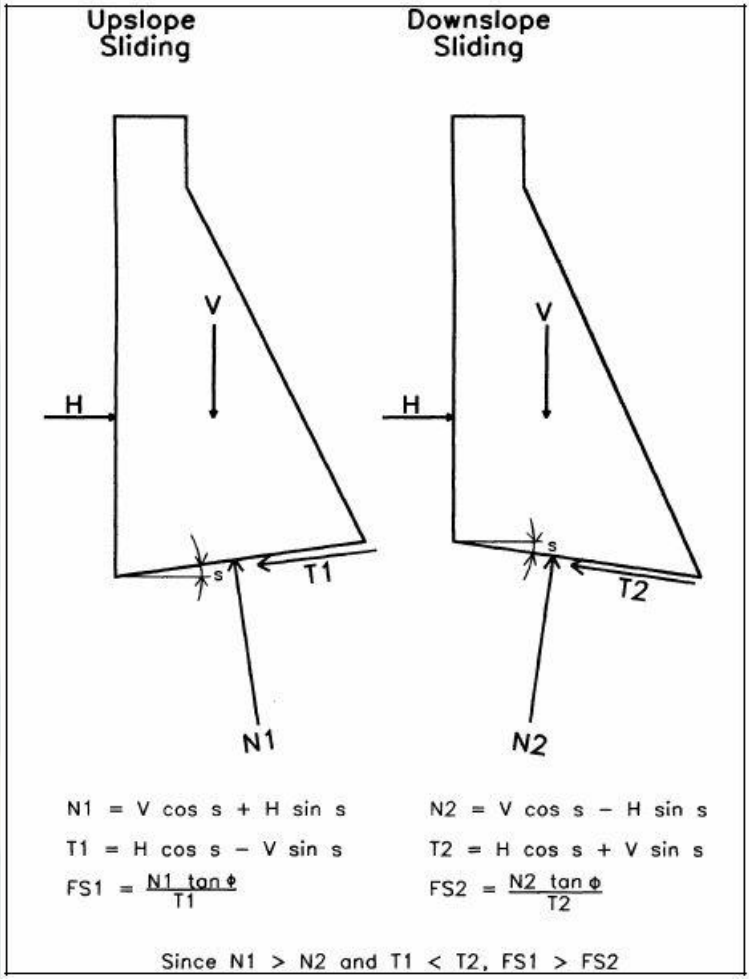
- 830 feet for one instrument
- 810 feet for all instruments

Limit values:

- All instruments under one mono above 810 feet

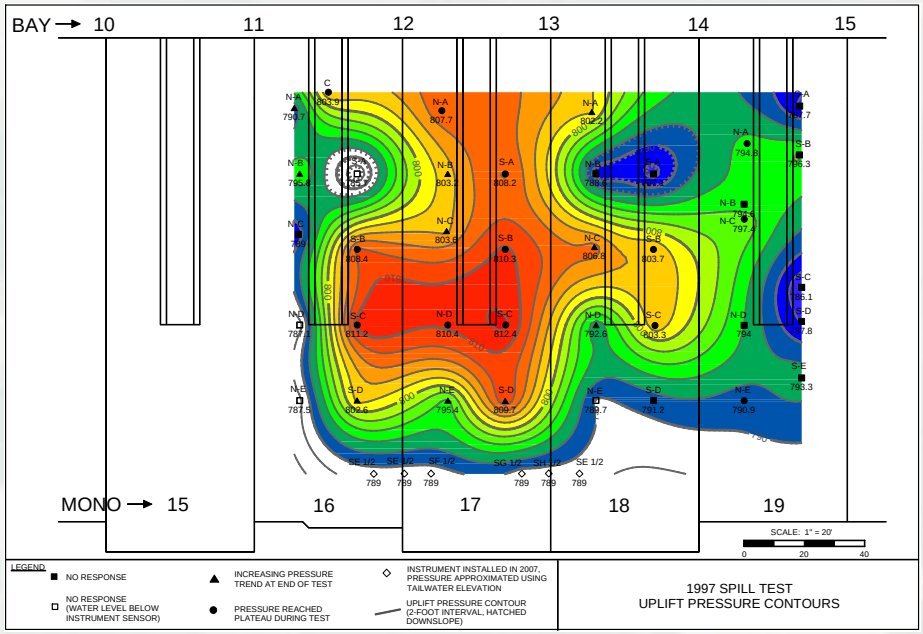
  Or

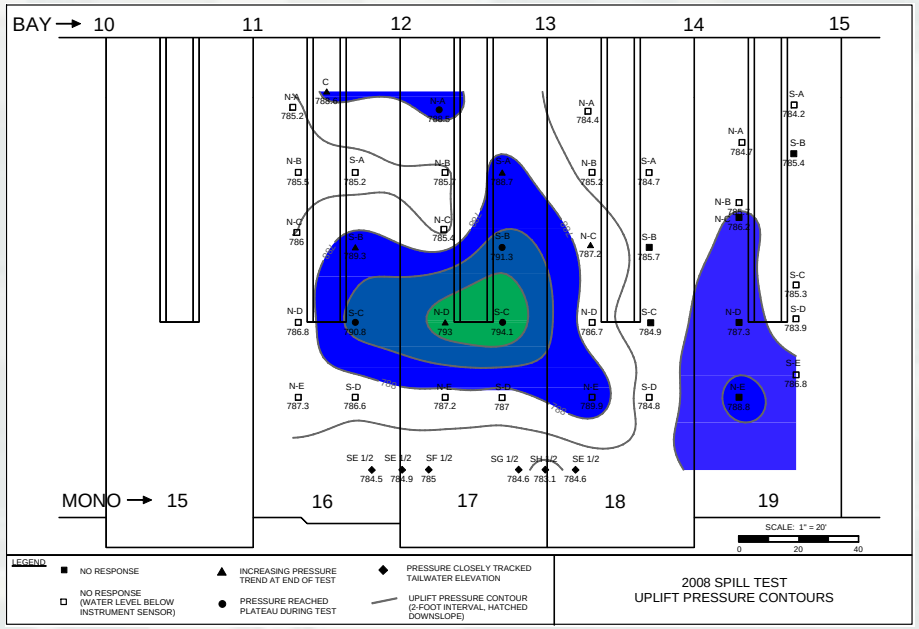
- An equivalent distribution of uplift that causes the sliding factor of safety to be less than 1.3



1. Based on analyses using EM 1110-2-2100 for sliding and floatation

Uplift History



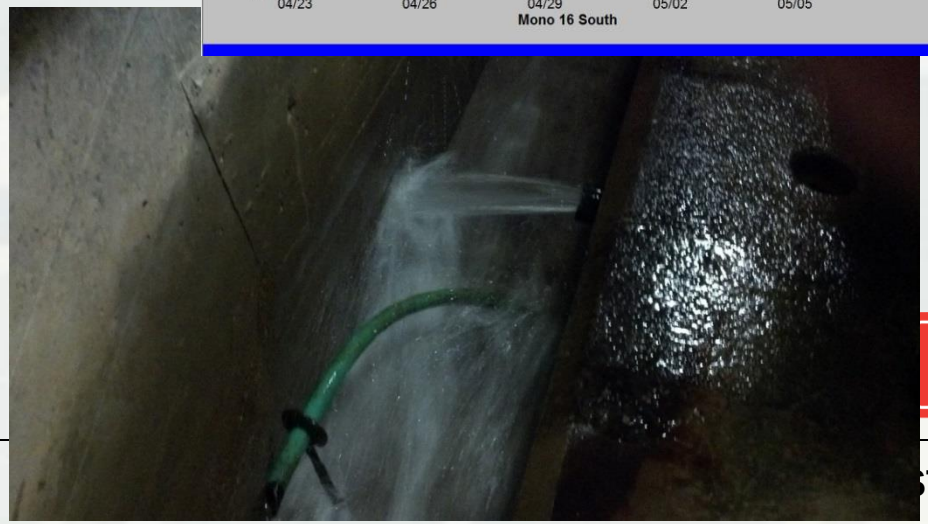


1997 pre-deflector & new joint seals

2008 post-deflector & new joint seals

Spill Monitoring

- Change uplift/joint movement instrument readings from daily to every 15 minutes.
- Review data once per day.
- Twice daily visual inspections of drainage gallery



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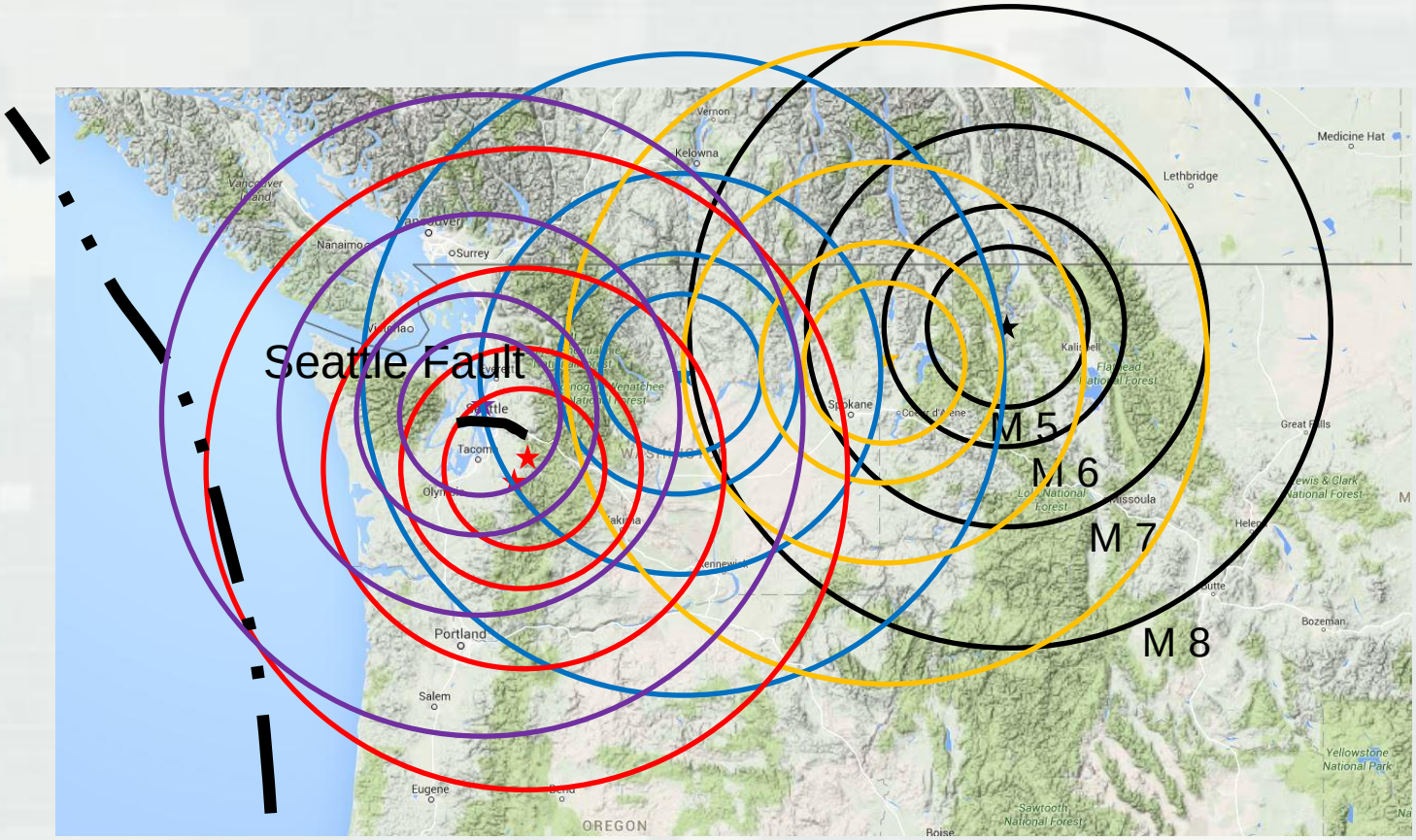
Earthquakes

- Post event inspection.
- Include mileage criteria and show possible earthquake sources near our projects.

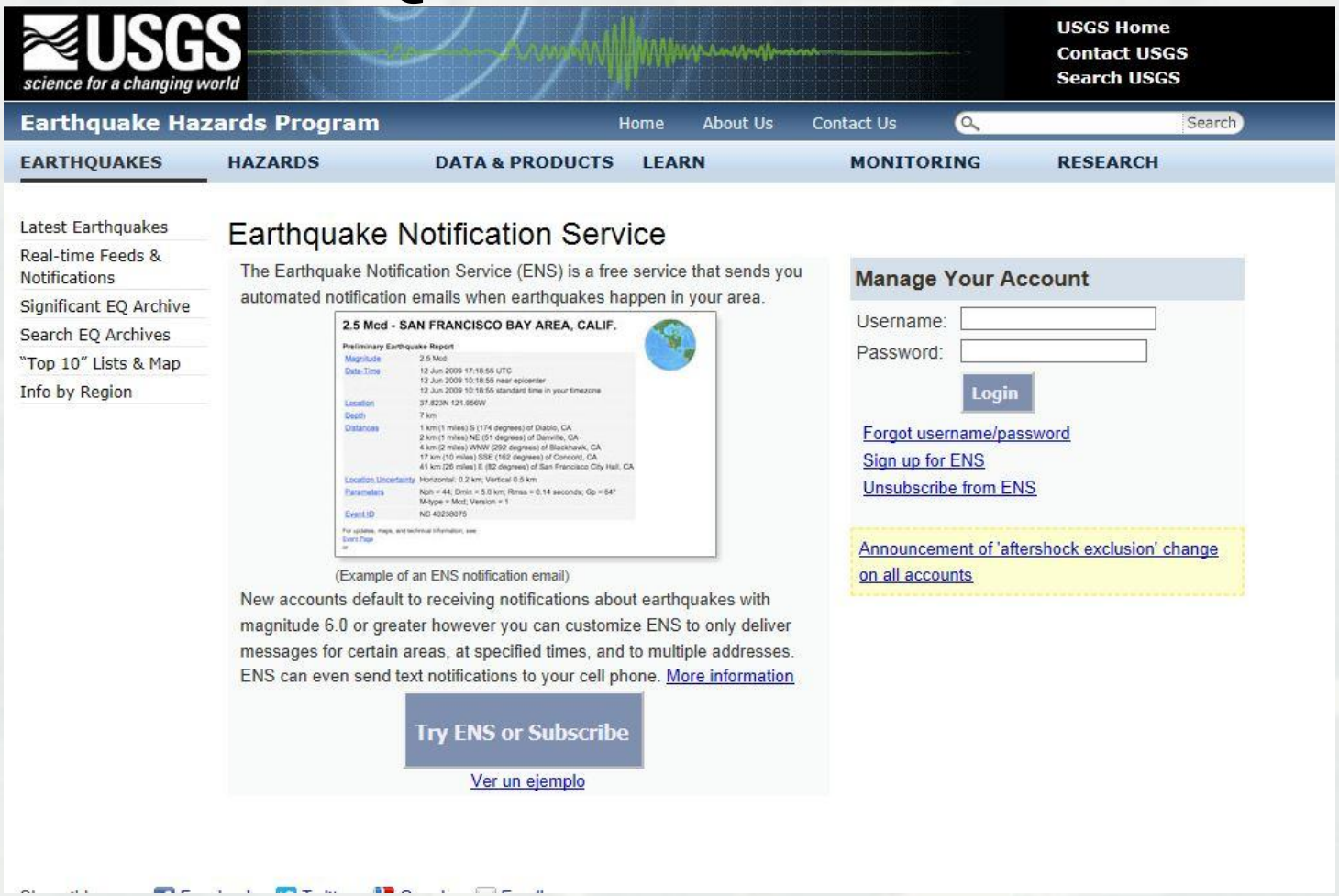
USACE EQ Inspection Requirements

Earthquake Magnitude	Epicenter Distance From the Dam (Miles) (Inspect dam if epicenter is within this distance to the dam.)
4.5	10
5.0	50
6.0	75
7.0	125
8.0	200

NWS projects



EQ Notification



https://sslearthquake.usgs.gov/ens/

Thank You for Your Attention